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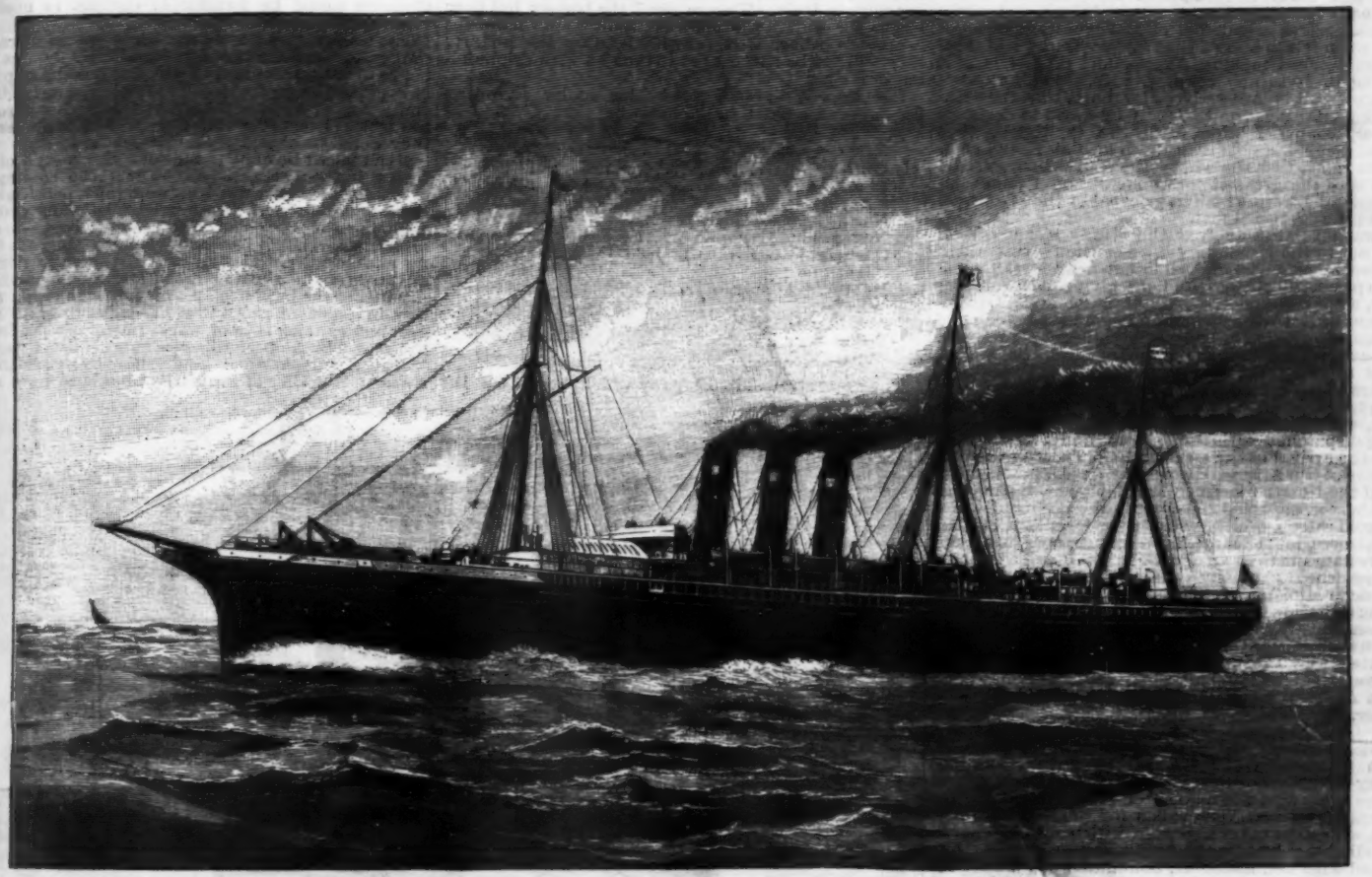
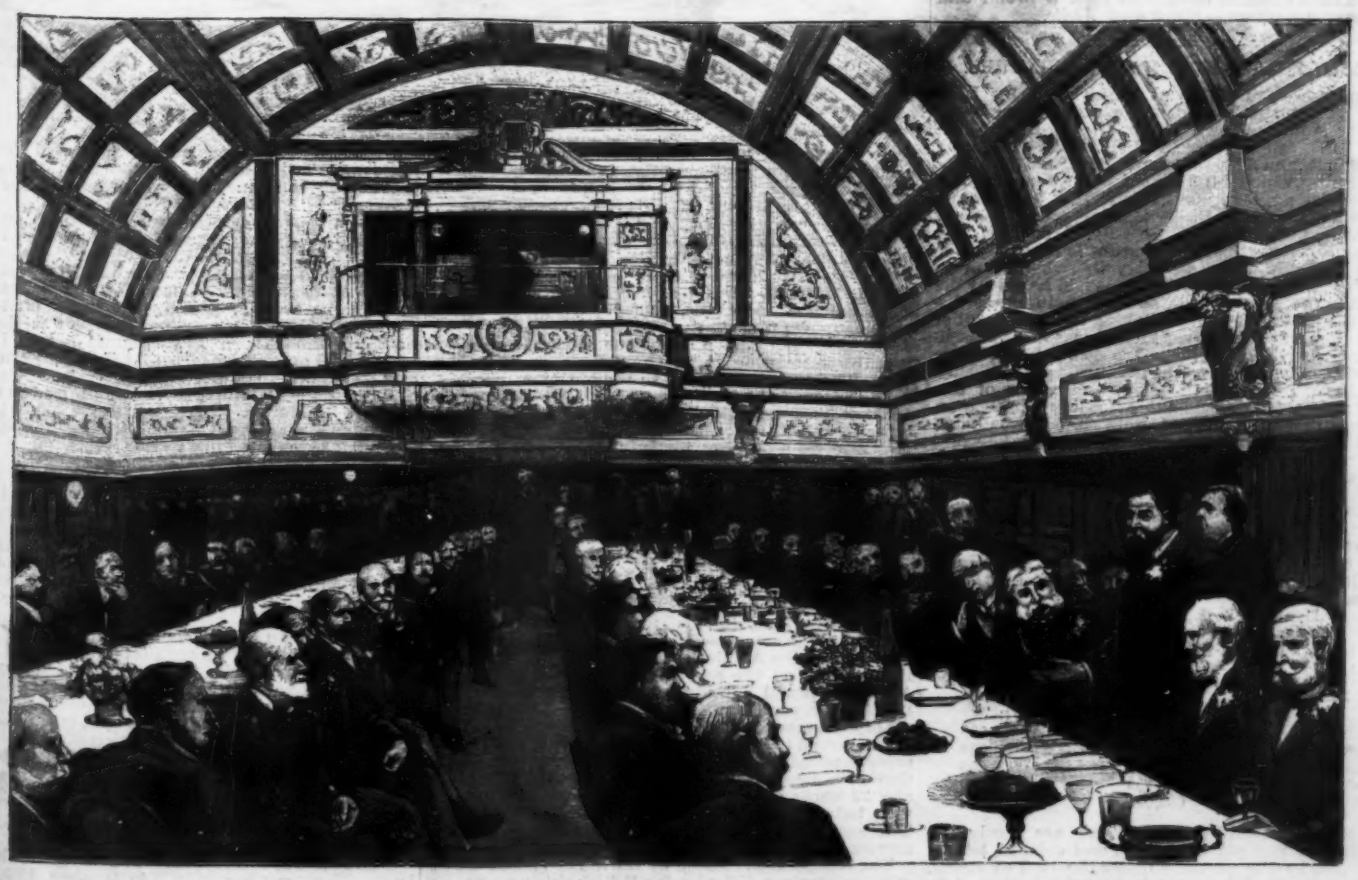


THE NEW YORK LEAVING SOUTHAMPTON ON HER FIRST VOYAGE ACROSS THE ATLANTIC UNDER THE AMERICAN FLAG.



MR. ROBERT LINCOLN, THE AMERICAN MINISTER, RESPONDING TO THE TOAST FOR "GOOD FEELING AND THE COMMERCIAL RELATIONSHIP BETWEEN THE UNITED STATES AND GREAT BRITAIN."

THE NEW TRANSATLANTIC SERVICE FROM SOUTHAMPTON.

THE AMERICAN STEAMER NEW YORK AT SOUTHAMPTON.

IN July, 1890, the Queen opened the magnificent Empress Dock, at Southampton, covering an area of eighteen and a half acres, with a minimum depth of twenty-six feet at low water. I remember on this auspicious occasion that a magnate of the iron road said: "This has been made for the railway company. In less than five years they will own all these docks." He was a true seer. Only a few months back Parliament gave assent for the transfer, at a cost of nearly a million and a half sterling, of the entire property to the Waterloo Board. Then came another surprise from Mr. Scotter's lucky bag. It was announced that a contract had been made by which the noble vessels of the Inman Company, henceforth to be known as the American, and carrying the United States mails, would abandon Liverpool after forty-three years sojourn there and make Southampton their English headquarters. Here was a masterstroke indeed, and all the shipping world wondered. But they wondered yet more when it was known that Messrs. Lucas and Aird had commenced making what would be the largest graving dock in any country, with adjoining quays rivaling those of Antwerp or Hamburg, that the General Steam Navigation Company intended to open up further communication with the Continent, that special trains were being made *en bloc* at East Leigh, and, in short, that the whole scheme had been cut and dried with the greatest forethought and liveliest intelligence. Liverpool might grieve, but the revolution was an accomplished fact.

It was on Saturday that the sturdy steamer Wolf went out to the Needles to welcome the New York to her new home. The night had fallen when the great ocean palace, all ablaze with light, giving back cheer for cheer, while the bands played "Hail Columbia," steamed proudly into the Solent and, amid the booming of cannon, the ringing of bells, and the ascent of fireworks took up her station in the Empress Dock, having on board two hundred and fifty passengers, over nine hundred bags of mails, and a full cargo. Alongside the quay three trains, the special mail, the Eagle Express, and the second-class were waiting, the mails being dispatched within one hour and two minutes from the arrival of the steamer. On Tuesday the proprietors of the American Company gave a luncheon on board the New York, when Mr. E. Taylor, the managing director, occupied the chair in the beautiful white and gold saloon, which, with its music gallery, exotics, and alcoves, looked more like a dining room in a London restaurant than an apartment on board a ship. A distinguished company was present, including the American Minister, the Hon. R. Lincoln, son of the famous President, the Mayor of Southampton, Mr. Lemon, Mr. Wyndham S. Portal, Chairman of the Southwestern, Sir Charles Tupper, Sir Stewart Macnaghten, Sir Donald Currie, M.P., Sir Barrington Simeon, General Marshall, Sir Eyre Massey Shaw, Mr. John Aird, M.P., Mr. Evans, M.P., the Hon. General Foster, Ex-Secretary of the U. S. Treasury, Mr. Arthur Guest, Colonel the Hon. H. B. Campbell, Mr. Charles Scotter, Judge Leonard, and many others, upon whom several ladies looked down from the pretty private box reserved for the better sex. Of course there was abundance of speech making. On Saturday the New York sailed for the Empire State, from which she takes her name, with many passengers, including two hundred Scandinavian emigrants. She carried with her, moreover, boundless good wishes for a prosperous voyage and a speedy return to the port which, thanks to unexampled enterprise, has been restored in such brilliant fashion to such a proud and well deserved position.—*Black and White.*

SUBSIDIES TO MERCHANT STEAMERS.

IT appears from a recent paper read by Lord Brassey before the Institution of Naval Architects, that the tonnage owned by Great Britain includes 9,506 sailing vessels, collectively measuring 3,602,546 tons, and 5,588 steamers, of 8,912,522 tons. The United States, which stand next in sailing tonnage, own 3,428 vessels, aggregating 1,166,963 tons. Germany, which stands next in steam tonnage, owns 765 ships, aggregating 1,091,472 tons. Broadly, it may be said that England owns half the mercantile tonnage of the world. When, however, we carry the comparison to those classes of ships on which we would be chiefly dependent in the event of war, and which in peace discharge the great function of linking nations together by the swift and safe conveyance of mails and passengers, our relative position is not so commanding as we could wish. According to the latest returns published by the Bureau Veritas, the merchant navies of the world possess 45 steamers exceeding 6,000 tons. Of these 10 are French, 1 Belgian, 7 German, and 27 English. Of the 10 largest steamships of the world 7 are British. Of the 14 ocean steamers of 19 knots speed and above engaged in the Atlantic trade, 6 are British, 3 German, 2 belong to the United States, and 1 to France. It will be seen that in the largest and swiftest ships we hold no uncontested supremacy. Supported by lavish subsidies, mail steamers sailing under other flags are running a closer race every year with the British lines of ocean steamers.

He had been supplied through the kindness of Mr. Henniker Heaton, M.P., with the following tables, giving the subsidies paid for mail services conducted under their national flag by the leading maritime States:

Name of State.	Amount paid.	Total foreign trade of the country.
	£	£
France	1,043,513	300,000,000
Germany	1,000,000	313,000,000
Russia	450,000	111,000,000
Italy	400,000	182,000,000
Great Britain	665,000	740,000,000

The subsidies paid by Great Britain are nearly covered by the receipts on foreign and colonial letters. In addition to the payment under the mail contracts, bounties are paid in several countries both for the construction of ships and in the form of mileage subsidies.

The premiums paid by the French government for the encouragement of navigation averaged from 1881 to 1890, £298,000 a year. It is proposed to extend the premiums for mileage sailed in the international coasting trade, where the distances exceed sixty miles; and it is estimated that the increase of expenditure will be not less than £60,000 a year. The number of lines of steamers not in receipt of mail subsidies has increased under the French flag from 2 to 19. The non-subsidized services extend to the Brazils, the River Plate, New York, the South Coast of America, China, and the Pacific. French naval officers applaud the system of subventions, because it calls into existence large numbers of steamers which will supply the navy with skilled firemen, who cannot be obtained from the Conscription Maritime, which consists mainly of fishermen.

A similar policy of bounties on construction has been accepted in Italy. The amount paid on the gross measurement of iron and steel vessels built in Italy is £2 per ton, and an additional premium is paid upon steamers of over 14 knots. He mentioned here that he had been connected with the building of three large sailing ships in Italy. They received the bounty, but they lost 30 per cent. in the contract, so he would leave his hearers to believe that notwithstanding the bounty, they will not be encouraged to proceed with shipbuilding in Italy.

The leading lines of steamships under European flags are enumerated in the following list:

Name of company.	Number of steamers.	Aggregate tons.
British India	103	240,000
P. and O.	36	216,000
Messageries Maritimes	61	202,000
North German Lloyd	68	197,000
Navigazione Generale	106	170,000
Compagnie Generale Transatlantique	66	167,000
Hamburg-American	86	165,000
Wilson	86	158,000
Austrian Lloyds	73	128,000
White Star	20	96,000
Cunard	26	86,000

The great steamship company which heads the list receives but scanty aid from the state. It does not, however, attempt to perform those splendid but costly feats of ocean steaming which we look for in ships such as are placed on the list of reserved cruisers. The P. and O. Company receives, under contracts with the British government, £340,000. The Messageries Maritimes Company receives subsidies amounting to £554,000 a year. The North German Lloyd receives subsidies amounting to £220,000 a year for services extending to Shanghai, Australia, and all parts of the Mediterranean. On the Eastern routes the speeds do not exceed 12 knots. The Navigazione Generale receives subsidies amounting to, in the aggregate, £380,000 a year. Their services extend to India, China, Batavia, and all parts of the Mediterranean. The Compagnie Generale Transatlantique receives subsidies amounting in the total to £446,320. The Hamburg-American Company receives a subsidy in accordance with services rendered, but the exact amount is not given in the estimates. The Wilson line, like the British India, is the noble creation of private enterprise, unaided by the state; but the vessels are not capable of high speed, and are not, therefore, convertible into cruisers. The Austrian Lloyds receives aggregate subsidies amounting to £130,000. The White Star and the Cunard companies receive payment from the Admiralty for those of their vessels which are placed upon the list of reserve merchant cruisers, and mail matter is paid for at rates settled in their contract. The Teutonic and Majestic receive from the Admiralty about £650, and from the Post Office, on the average, £1,000 per voyage. The American postal subsidy will give the Inman line £2,480 per voyage for 20 knot steamers. By a recent act of Congress the City of Paris and City of New York were allowed to hoist the Stars and Stripes. By the same enactment it was stipulated that, in consideration of a liberal subsidy, two steamers of 12,000 tons and 22 knots should be built in America for the service between the United States and British ports. Three other steamers are to be built in America for the service between New York and Antwerp.

The competition created by the aid of subsidies constitutes a serious difficulty for British ship owners. By able management, such companies as the White Star, Cunard, P. & O. and others have thus far been able to hold their own. It may be necessary to grant larger subsidies in the future for the conveyance of mails under the British flag. It would not be politic to allow these services to be taken entirely out of the hands of our own ship owners by foreign rivals. It redounds to the credit of British ship owners and ship builders that they have been able to keep the national flag well to the fore in the face of the increasing competition of foreign services. Under the British flag, among the most important additions to our fleet of fast steamers are two ships lately built for the P. & O. Company of 7,000 tons and 18 knots. The Cunard Steamship Company are about to put on their Atlantic service two ships which will, for the present at least, have no rivals. Their tonnage is 12,500, horse power 30,000 indicated, speed 22 knots. The White Star contemplate building two vessels of still greater power and speed.

Subsidized mail steamers cannot be a match for regular built vessels of war. They have large hatchways, and are not protected by armored decks and by minute subdivision into compartments. Armed merchant steamers would be formidable enemies to unarmed vessels of the same class.

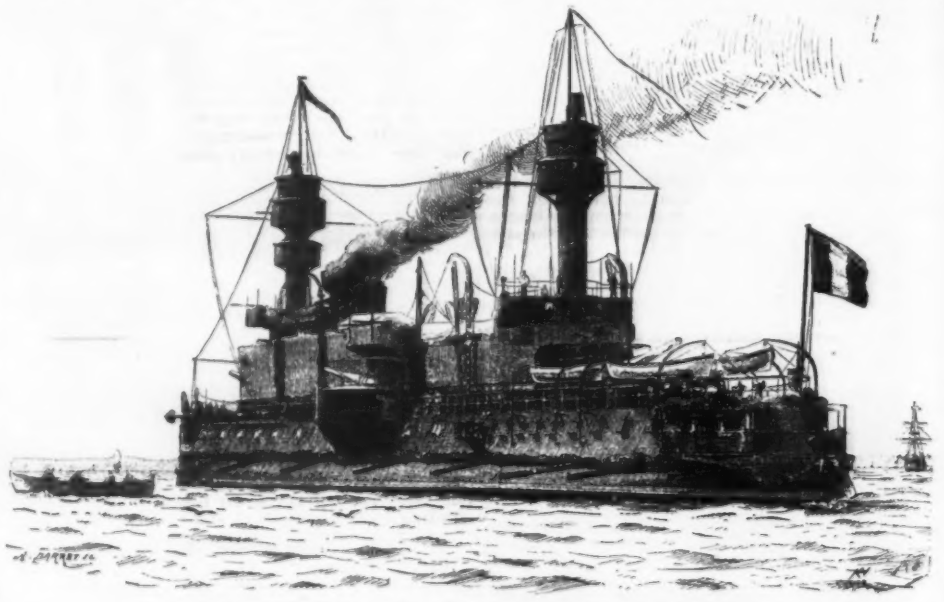
The proper *role* for mercantile auxiliaries was described by Lord George Hamilton in moving the estimates in the session of 1889. They would be employed in dogging the footsteps of a foreign merchantman, embarrassing a foe, and keeping touch with a squadron which has broken blockade. For such services they would be absolutely invaluable.

Much might be done to improve the means of protection in the mercantile auxiliary if the contingency of employment as a warship were fully considered in the original design. Decks might be built over the engine and boiler rooms of sufficient strength to carry armor, which could be fitted when the ship was taken up as a cruiser. The frames of the ships might be adapted for the riveting up of additional bulkheads. Admitting the imperfections of the mercantile auxiliary in point of protection, the superiority in speed over any existing ship of war is incontestable. During the year 1892 the performances of the fastest steamers in the North Atlantic trade show many remarkable results. The City of Paris may be said to have maintained nearly 20 knots as an average speed. The Majestic and Teutonic, of the White Star line, have approximately the same speed as the two famous Inman steamers.

These fine performances are fairly rivaled, and, if we look to the date of launching, are surpassed by the Umbria, built in 1884, which recently, on her eighty-second voyage, ran from Queenstown to New York in five days and twenty-two hours. Not more than four hours have been gained by the liners built subsequently to the Umbria. The Touraine is the greyhound of the French Transatlantic liners. She has maintained an average of 19·59 knots between Havre and New York. On the route between Cape Town and Southampton the Scot has maintained an average speed of 17·2 knots. The Ibex, which plies between Weymouth and the Channel Islands, is capable of steaming 23 knots an hour. She would make an admirable look-out ship.

It has been thought expedient to bring the subject treated in this paper under the consideration of the Institute of Naval Architects, because a disposition has been shown in certain quarters to question the policy of subsidizing mercantile auxiliaries and giving subventions to mail steamers. Without the help of the state it would be impossible to compete with the highly subsidized mail steamers running under foreign flags.

Public opinion in this country will probably share the view held in the United States, and which has recently found expression in language which may be appropriately quoted from the report of the committee of Congress: "A mercantile marine of our own, ably manned and used by our own people, is a national requirement, essential to a fair participation in the trade of the world, indispensable to wise industrial economy and vital to the importance and advance of our country."



THE FRENCH WAR STEAMER NEPTUNE.

THE FRENCH IRONCLAD NEPTUNE.

THE Neptune is a first-class ironclad of the Marceau type. Work was begun on it in October, 1880, and it was launched in May, 1887. It has only just now been placed in line. Last year some modifications were made in the offensive and the defensive armament. Its 14 cm. guns were sent to Ruelle to be changed in-

to rapid-firing guns. The commander's *blockhouse* was covered with steel 12 cm. thick. It appears, in fact, that this vessel lacked protection at the base of the barbette tower and of the secondary armament, and means of communication with and command of the machinery and motors. What really constitutes the weak side of this great ironclad is the small provision for coal (little more than 600 tons).

The following are the principal data of this vessel: Length, 335 ft.; breadth, 66 ft.; draught, 27 ft.; displacement, 10,630 tons. The engines develop 12,000 h. p.; speed, 16·5 knots; two screws. Thickness of the armor belt, 14 in., of towers, 11 in., of bridge, 3 in.

Armament: Four 34 cm. guns; seventeen 14 cm. rapid-firing guns; eight 37 mm. revolvers; fourteen rapid-firing 65 mm. and 47 mm. guns; four torpedo tubes. The crew consists of 660 men.

THE DEPARTURE OF COLUMBUS FROM PALOS.

APROPOS of the Columbian festivities which are now occupying the public attention, we give an engraving from the celebrated painting by Gisbert, of the departure of Columbus from the port of Palos on his first memorable voyage of discovery. This notable event took place in the early morning of August 3, 1492. We are indebted to *La Ilustracion Espanola* for our engraving.

AN ELECTRIC FIRE ENGINE.

THE engine illustrated has been designed by Messrs. Merryweather & Sons, of London, for use in towns and districts lighted by electricity. It is fitted with a powerful Siemens electric motor, driving a pair of Merryweather's special rotary pumps, and is capable of throwing 350 to 500 gallons of water per minute to a height of 170 ft. in a single jet, or of throwing as many as four jets to a less height.

The pumps are of gun metal, with valves and waterways of the same material, and are fitted with pressure gauges, capacious copper air vessels, and screwed outlets, for the attachment of suction and delivery hoses. The carriage is of the same pattern as that supplied to the Metropolitan Fire Brigade; but modified so as to carry a motor and pumps instead of the boiler and machinery of the ordinary steam fire engine. It is intended to be drawn by a pair of horses to fires, and, on arrival, lengths of electric cable, carried on the engine, are attached to the electric light wires, and the pumps can therefore be started in a few seconds, in fact, in less time than the hose connections can be made.

Our illustration shows the machine pumping water from a portable canvas dam, placed in the street, the dam being supplied with water from street hydrants. The engine can also be used by connecting the suction hose direct to the street hydrant, provided the supply is sufficient. This engine can also be used for water supply purposes, being especially suitable in cases where power can be obtained from a distance; and Messrs. Merryweather & Sons inform us that they have fitted up several pumps of this system in country mansions, where water power is obtainable. This water power has been used to drive water wheels, or turbines, which, in their turn, drive a dynamo, wires being carried to a position near the house, and the electric engine placed over a well, or near any other source of supply, to pump water into tanks or reservoirs, for household use and fire protective purposes.—*Electrical Industry.*

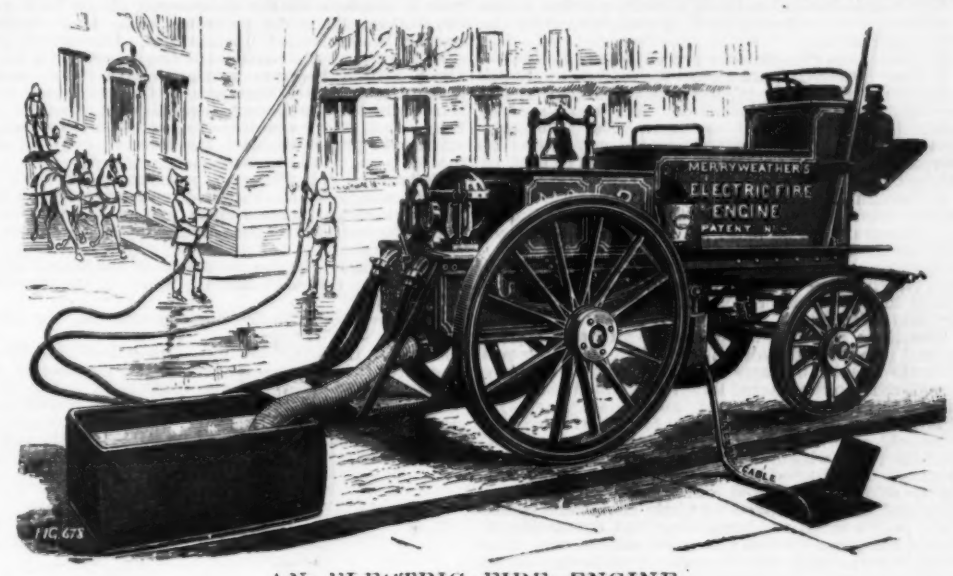
The St. Gothard tunnel is nine and one-fourth miles long; began, 1870; opened, 1881.

PURIFICATION OF MERCURY.*

By M. W. JAEGER.

AT the German Physico-Technical Institute the mercury intended for exact measurements (the construction of standard resistances, barometers, etc.) is subjected to the following purifying processes. The metal used is mercury sent from the Idria mine in iron bottles, and is of very good quality and fit for use for most purposes after simple filtration.

In order to eliminate the heavy metals which may exist in it, the mercury after having been filtered and dried is first subjected to a double distillation *in vacuo*. In this operation it is necessary to avoid the slightest trace of grease or other impurities which might be introduced through greased taps or India rubber tubes. For this reason a mercury pump without any tap is used, the closing being effected by means of columns of mercury; the connection between the pump and the distilling apparatus is also made entirely of glass without any tap. After the air is exhausted the communicating tube is drawn out and sealed hermetically.



AN ELECTRIC FIRE ENGINE.

FIG. 1.

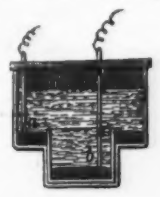


FIG. 2.

* *La Lumiere Electrique.—Electrical Review.*

As mercury, purified by distillation, may still contain electropositive metals (alkalies, zinc, etc.), it was thought necessary to subject the metal to a second purification by electrolysis in order to dissolve these impurities. The liquid used for this purpose is a mercurial solution of nitrate, obtained by the action of nitric acid on mercury in excess.

In order to render the current density as small as possible, the current was divided between four vessels of the same dimensions. These vessels were formed of an outer glass cylinder, A (Fig. 1), about 19 centimeters in diameter and 11 high, containing the mercury purified by distillation and serving as anode, and another inner glass cylinder, B, 9 centimeters in diameter and 3 high.

This latter contains the platinum cathode, *a*, wound in a spiral.

When a certain quantity of mercury has been deposited, so that the bottom of the inner vessel is entirely covered with it, its whole surface acts as a cathode, and the density of current is still lower. The current is conveyed to the mercury in the outer vessel by another platinum wire, *b*, insulated from the liquid by a glass tube. The total surface of the cathode is thus 260 square centimeters, that of the anode 900 square centimeters. The source of the current was a Gulcher thermo-electric battery, which, with an internal resistance of only 0·4 of an ohm, gives from 3·6 to 4 volts. By means of a resistance the current was maintained at about 1 ampere. At times it went up to 3 amperes. With this last intensity the deposit of mercury was again effected under good conditions. (In this last case, the density of current is about 0·12 of an ampere per square centimeter for the cathode and 0·003 for the anode.)

One drawback to this method is that at the end of a certain time the anode becomes covered with basic salt, which eventually entirely stops the current. The liquid surrounding the anode becomes more and more concentrated and only spreads upward very slowly,

THE DEPARTURE OF COLUMBUS FROM PALOS.—FROM THE PAINTING BY GISBERT.

while the excess of salt is being precipitated. This defect can be remedied by another arrangement as shown in Fig. 2. When the anode, *a*, is at a higher level than the cathode, *b*, the solution concentrated by the current descends in consequence of its greater density and displaces the weak solution in the inner glass, so that with this arrangement a continuous flow of liquid is established.

The chemical examination of mercury purified in this manner has been effected by M. Mylius, who gives the following results.

To detect heavy metals we proceeded as follows:

1. Two hundred grammes of the material were distilled in a current of oxygen; a few milligrammes of crystallized oxide were obtained. This was dissolved without any residuum in the nitric acid. The solution evaporated in a porcelain crucible and heated up to volatilization of the mercury, left no trace of residuum.

2. Two hundred grammes of the material were treated at a low temperature with diluted nitric acid until only two grammes of material were left undissolved; this remainder, which would contain the platinum, if there were any, from the electrodes, was separated and dissolved in nitric acid; on being evaporated and volatilized in a porcelain crucible, the solution left no appreciable residuum.

The other part of the nitrous (nitrate) solution was poured into diluted hydrochloric acid. The mercurial chloride washed in water was quite capable of being volatilized; to the filtered liquid was added some ammonia. The precipitate of ammoniacs, mercurial chloride, was heated with diluted formic acid and mercurial chloride was obtained, which was separated by filtration, and which, on being volatilized, left no residuum. The filtered liquids containing ammonia and formic acid were collected and evaporated. The ammoniacal salts, destroyed by nitric acid, were volatilized; only a small residuum remained, containing alkalies, lime, and silicium; these substances were attributable to the glass vessels used. The foreign metals constituting the impurities of the mercury would be contained in this residuum, the systematic analysis of this latter revealed merely traces of iron; it is probable that this was attributable to the employment of various iron utensils in the course of the operations. In 200 grammes of purified mercury no impurity consisting of any heavy metal was to be found; the spectral analysis for the detection of light metals has not yet been made. The Idria mercury, taken directly from the iron bottles, is very pure, but it leaves after volatilization an appreciable residuum.

[FROM ENGINEERING, LONDON.]

THE BERNE COMPRESSED AIR TRAMWAY.

By C. S. DU RICHE PRELLER, M.A., Ph.D., Assoc. M. Inst. C.E.

THE city of Berne, picturesquely situated on a long and narrow rocky eminence, 1,760 ft. above sea level and 115 ft. above the River Aare, by which it is almost completely surrounded, does not easily lend itself to the working of tramways, and the numerous suburbs on the other bank of the river can only be connected with the town by high and costly bridges, the difficulty being enhanced by the very uneven ground on both sides. When, therefore, after several abortive attempts, a concession for a system of urban and suburban tramways was at last granted by the local and federal authorities in the year 1889, the Swiss company formed to carry it out instituted a careful inquiry, with the view of determining once for all the mode of mechanical traction best suited to local conditions, seeing that the rising and falling gradients of 5 to 6 per cent. precluded horse traction *a priori*. Cable traction would have been not only too costly, but unsuitable on other grounds, and the same objection applied to electric traction by underground conductors; while the local authorities declined to allow overhead wires, and traction by electric accumulators was, by general consent, as it is to this day, recognized to have proved a failure.

Under these circumstances, the company adopted Mekarski's system of traction by compressed air motors, which had already been applied at Nantes, and more recently on the Paris, Vincennes, and Nogent suburban road railways. These two lines, however, are essentially level, whereas the Berne tramway is the first instance of the compressed air system being put to the test on steep grades, and has, therefore, deservedly attracted considerable interest among engineers, the more so as it claims to have effectually solved the problem of noiseless and smokeless street car motors without the inconvenience attending steam cars, as well as overhead or underground conductors. The main line within the town, traversing the latter lengthways (Figs. 1 and 2), is on the meter gauge, and constitutes the nucleus of the system. It was opened toward the end of the year 1890, after considerable delay caused by the novel conditions to which the compressed air system had to be adapted; and the recently published official returns of a complete twelve months' working admit of a correct opinion being formed as regards the merits claimed for the system *per se*, as well as the first cost and working expenditure of the line and compressed air plant, all of which the writer recently had occasion to thoroughly investigate.

Principles of System.—The leading principle of Mekarski's system is to use as motive power atmospheric air, which, after being compressed by stationary air pumps, is mixed with steam and then loaded into storage cylinders which are carried under the floor of the motor cars, and whence the air passes into and actuates a pair of outside cylinders, whose piston rods are coupled with the driving axles, and thus propel the car. Hence the name "automobile" given to these motor cars.

The maximum pressure under which the air is thus used on the Berne tramway is 30 kilos. per square centimeter (30 atmospheres), equal to 440 lb. per square inch. The addition of a certain quantity of steam, which is a distinctive feature of Mekarski's system, is effected for the purpose of maintaining the air at a constant and sufficiently high temperature, whereby the expansion of the compressed air is governed by and takes place pretty nearly according to the law of isothermal alteration. Without this admixture of steam, the temperature of the compressed air would, according to Poisson's formula of the relation of the initial volume (V^1) and the final volume (V^2) of air during its process of expansion

$$\frac{273 \times \text{temp. } V^1}{273 \times \text{temp. } V^2} = \left(\frac{V^1}{V^2}\right)^{0.41}$$

drop so rapidly that for purposes of motive power it would be practically useless. The requisite temperature is obtained by the compressed air, on its way to the working or motor cylinders, being made to pass through water heated up to 165° C. During this process, the air, taking particles of the superheated water along with it, becomes saturated with steam, which subsequently partly condenses, so that its latent heat is absorbed by the compressed air as it expands. In this way any appreciable cooling of the temperature is effectually prevented, and the tractive force of the motors is considerably increased.

Primary Motive Power.—The motive power for driving the compressors is supplied by the new hydro-electric works of the Berne corporation, which are situated about 400 yards above the loading depot or terminus of the tramway (Fig. 1), and utilize the water power of the River Aare to the extent of 20 cubic meters per second at a fall of 2 meters, which gives therefore $\frac{20 \times 2 \times 1{,}000}{75} \times 0{\cdot}7 = 370$ horse power on the main shaft. Of the three 120 horse power Jonval turbines, two drive the dynamos for the electric lighting of the town, while the power of the third is let to the tramway company at the rate of 100 francs or 4*l.* per horse power per annum. This power is transmitted to the compressing station, situated about 70 yards higher up the river, by a main shaft 60 meters in length and 12 centimeters (4·71 in.) in diameter.

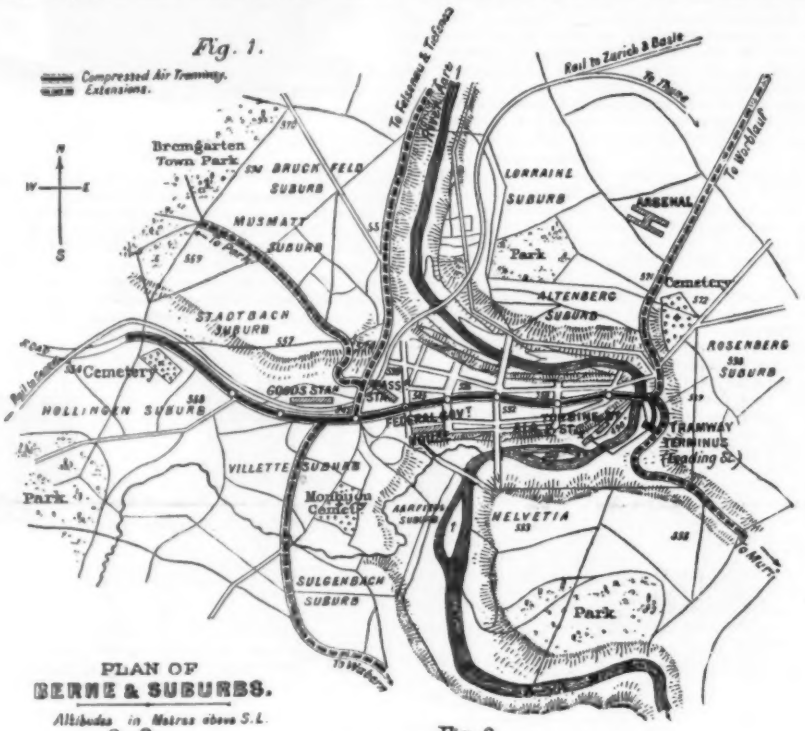
Compressing Station (Figs. 3 and 4).—The main shaft of the turbine station drives the main shaft of the compressing station by four belts, one to each of the four air pumps, the turbine shaft making 130 revolutions and the main shaft of the compressing station, of the same diameter, making 207 revolutions per minute. From this latter, each of the four compressing pumps is actuated by separate pinion gearing, and by means of friction couplings on the turbine as well as on the pumping main shaft, the air pumps can be worked separately or jointly according to requirement. The number of strokes of the horizontal pumps is 80 per minute, and the motive power required by each works out at 35 horse power. Each pump has two single-stroke cylinders placed lengthways, one after the other; the first, whose piston, 30 centimeters or 11·8 in. in diameter, presses the atmospheric air into a spherical-shaped air chamber, which surmounts the cylinder, at a pressure of 5 atmospheres, or 73 lb. per square inch; and the second, smaller cylinder, whose piston, on the same axis as the first, but only 13·5 centimeters, or 5·3 in., in diameter, compresses the air at the forward stroke to the maximum of 32 atmospheres, or 469 lb. per square inch. This maximum is two atmospheres, or 29 lb. per square inch, in excess of the maximum at which the cars are loaded at the depot, the margin being allowed for loss during the passage from the compressing to the loading station, so that at the latter the cars may be loaded at the full pressure of 30 atmospheres, or 440 lb. per square inch.

As the temperature of the air increases during the process of compression in the same ratio as it falls during the process of expansion, provision is made for cooling the air as it passes through the cylinders, and this is done by slightly mixing it with water in the first and larger cylinder, while in the second and smaller cylinder the cooling is effected from outside by a water casing, the same water serving for both cylinders. By this means the temperature of the air on emerging from the pumps is kept within 40° C. The pressure in the two cylinders is regulated by a safety valve to each; and the quantity of air compressed by each pump per hour is about 100 kilogrammes, or 352 lb.—equal to an efficiency of 88·5, or about 90 per cent. It was at first estimated that two pumps equal to 70 horse power, or 320 kilogrammes of air, would suffice for the ordinary ten minutes' service of the tramway; indeed it appears that Mons. Mekarski's own estimate was only 50 horse power, and consequently the installation consisted originally only of two pumps with an additional third as reserve; but the official trials showed that at least 60 kilogrammes, or a margin of about 25 per cent., was necessary to cover the deficiency of pressure and insure the regularity of the service under unfavorable conditions. Accordingly a fourth pump was added to the installation, and three compressing pumps, equal to 105 horse power, are now kept working for the ordinary service, a fourth being kept in reserve.

On leaving the pumps, the compressed air passes first through two upright drying chambers 48 centimeters or 18·9 in. in diameter, for the purpose of being freed from water, this being effected by a series of obstacles which cause the water to separate from the air on its passage through the chambers. From here the compressed dry air passes into two adjoining iron plate reservoirs 80 centimeters or 31·4 in. in diameter, and 1·25 cubic meters or 44·15 cubic feet capacity, where it is stored for the purpose of equalizing any difference of pressure due to the pumps, thus insuring that the pressure of the air, when arriving at the loading station, is practically constant. The wrought iron main, 3·2 centimeters or 1·3 in. in inside diameter, which conveys the air from the compressing station on the left bank to the loading station on the right bank of the River Aare, crosses that river by an iron bridge 52 meters in length, erected for the purpose, and then runs underground and with a rise of five per cent. along the right bank, the length being 530 meters and the difference of level 25 meters, or 83 ft. For the better protection against frost, it is covered with a lead casing, and on the bridge is, moreover, embedded in an ashpan. This main has been substituted for the original wrought iron pipe of the same diameter, which was laid partly underground along the left bank of the river, but, being covered only with gutta percha at the joints, gave rise to frequent interruptions during the first winter season, owing to ice forming inside the pipe. This old main now serves as reserve. The air compressing pumps, as well as the mains, were tested for pressure up to 35·5 atmospheres or 522 lb. per square inch.

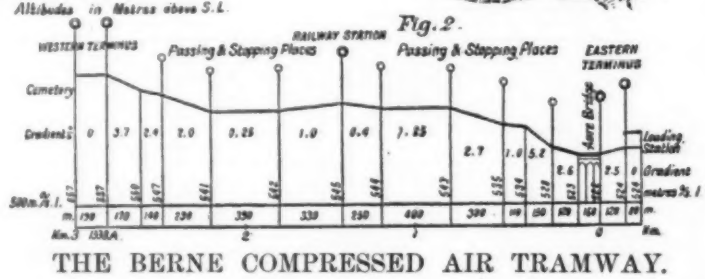
Accumulator and Boiler Station (Figs. 5 and 6).—This is situated at the eastern terminus of the line, at the back of the car shed, and contiguous to the loading station. The so-called accumulator battery is composed of six upright circular chambers or reservoirs, arranged in two sets of three reservoirs each, which are of riveted iron plates 1·4 centimeters or 0·52 in. in thickness. Like the two reservoirs in the compressing station, they are 80 centimeters or 31·4 in. in diameter, and 1·25 cubic meters or 44·15 cubic feet capacity. They are tested for a pressure up to 40 atmospheres or 588 lb. per square inch, and serve, on the one hand, to store the surplus air supplied by the compressing sta-

Fig. 1.



PLAN OF BERNE & SUBURBS.

Fig. 2.

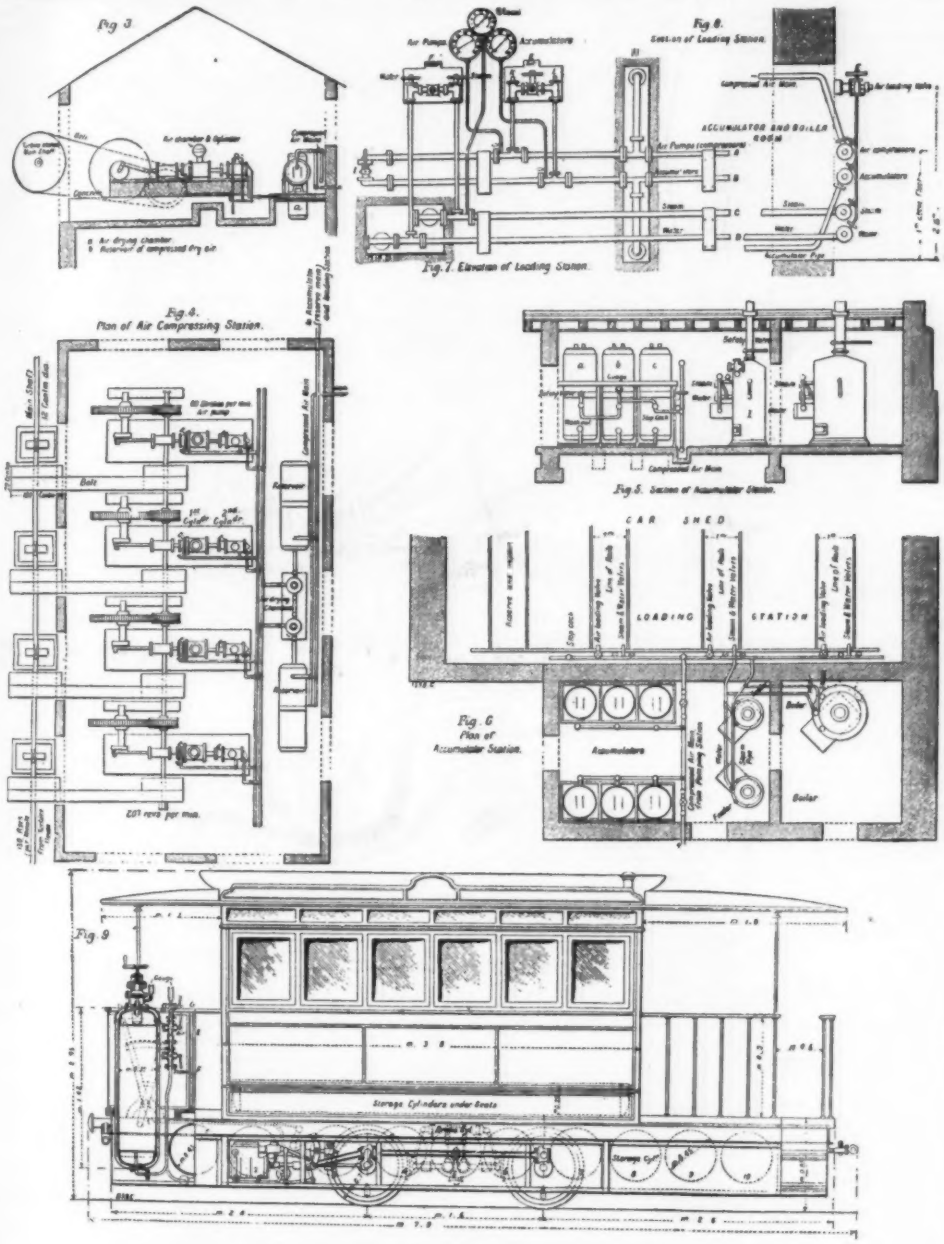


THE BERNE COMPRESSED AIR TRAMWAY.

tion and not required for immediate consumption by the cars, and, on the other, to equalize the pressure of the residue air contained in the cylinders of the cars returning for reloading. This equalizing process has to be effected every time before a car is reloaded direct from the compressed air main.

The accumulator room further contains three upright boilers, of which the two smaller ones have a heating surface of 3·2 square meters or 35·5 square feet each, while that of the third and large one is 9 square meters or 97 square feet, all three being constructed for a pressure up to 7 atmospheres or 103 lb. per square inch. They supply the requisite steam and water for the upright heating chamber which each car carries on the front platform for the purpose of mixing the air with steam, and thereby maintaining it at the required temperature. Of the three boilers, the two smaller, or the large one, are alternately used for the ordinary service. The original installation consisted only of the two small boilers, of which one was used as reserve. It was, however, found that, especially in the morning, when all the cars in service have to be loaded simultaneously, one boiler was inadequate, and hence a large third one had to be added.

Car Shed and Loading Station (Figs. 6, 7, and 8).—The car shed, to which are attached a repair shop and



THE BERNE COMPRESSED AIR TRAMWAY.

the company's offices, contains four parallel lines of rails, provided with a cleaning pit each, and intercommunicating by a traveling platform, and a turntable, there being no outside space for sidings. Of the four lines of rails, three are loading lines, two being used during the day exclusively for the cars running in for loading and out for service, while the third line of rails is used for one or two cars standing always ready loaded in case of accident or special service, and the fourth line serves for the empty reserve cars and those undergoing repair.

The loading station (Figs. 7 and 8) is placed at the end of, and transversely to, the three loading lines of rails, viz., contiguous to the wall which separates the accumulator and boiler room from the car shed. It consists of four superposed horizontal pipes of 3 centimeters or 1·2 in. inside diameter, running along the wall, and of the gauge, regulator, and valve apparatus surmounting them, and fitted in the center. The uppermost of the pipes, A, connects direct with the main from the air compressing station, which passes through the accumulator room, and there also connects with the accumulator battery. The second pipe, B, connects with the accumulators, but is also connected with the compressed air main; the third, C, is the steam pipe, and the fourth, D, the water pipe, both connecting with the boilers in the accumulator room. The discharge from these pipes—viz., the loading of the cars—takes place through upright connecting pipes and two valves governed by two corresponding sets of regulators marked "Water" and "Air" respectively, the pressure in the compressed air accumulator and steam pipes being registered by three corresponding pressure gauges fitted above the valves and regulators. It may be added that, there being only one valve regulator and gauge apparatus for the three lines of rails, one car only, stationed on one or other line, can be loaded at the time, the connections of the other two lines being cut off in the meantime. This is a disadvantage, especially when an increased ordinary or an extraordinary traffic on special occasions requires the dispatching of several loaded cars in quick succession; and to meet this contingency, each line of rails should be provided with its own regulator, valve, and gauge apparatus, so as to enable two or three cars to be loaded simultaneously.

Motor Cars (Fig. 9).—The car, with its front and back platforms, rests on two iron frames, an outside and inside center one. The lower edge of the outside frame, composed of girders and angle irons, with diagonal bracing, is 15 centimeters or 5·9 in. above the head of the rails, so that the compressed air cylinders, as well as the motors, are effectually concealed and protected. The smaller inside center frame serves for the axle bearings, the motor cylinders being placed between the two frames.

1. *Motors.*—The engine is constructed on the model of an ordinary steam locomotive, and drives two coupled axles, the wheel base being 1·6 meters or 5·2 ft. It has a pair of outside horizontal cylinders, and its leading dimensions are as follows: Diameter of wheels, 70 centimeters or 27·5 in.; length of stroke, 22 centimeters or 8·6 in.; and diameter of cylinders, 13 centimeters or 5·1 in. The total weight of the car when full is about 9·5 tons; the authorized speed is 11 kilometers per hour, or 3 meters per second. Taking the resistance due to the grooved tramway rails and to curves under unfavorable conditions at 14 kilogrammes per ton of car weight, the engine has to overcome on the steepest (5·2 per cent.) grade section of the line a total resistance of $9{\cdot}5 \times (52 + 14) = 627$ kilogrammes, or about 0·63 ton, and has to develop $\frac{627 \times 3}{75} = 25$ horse power. At the maximum authorized working pressure in cylinders of 12 atmospheres or 176 lb. per square inch, the motors can develop a tractive force of $\frac{13^2 \times 22}{70} \times 12 = 636$ kilogrammes, or 0·64 ton; this maximum is, therefore, just sufficient to take the car up the 5·2 per cent. grade, while on the flatter sections of the line the working pressure does not exceed 5·5 to 10 atmospheres or 73 lb. to 147 lb. per square inch. Sand has to be frequently used to increase the adhesion on the 2 to 5 per cent. grades.

2. *Storage Cylinders.*—Between the two car frames are suspended ten horizontal compressed air storage cylinders, varying in length according to the available space, but of uniform inside diameter of 45 centimeters or 17·7 in., composed of riveted 7 millimeter or 0·27 in. sheet iron, and tested for pressure up to 40 atmospheres or 588 lb. per square inch. These 10 storage cylinders have a collective capacity of 1·82 cubic meters, or 64·25 cubic feet, which, according to M. Mekarski's estimate, should have been sufficient for a double journey (6 kilometers) over the line. The trial trips, however, showed this estimate to be inadequate in practice, and two further small storage cylinders had therefore to be added, of 25 centimeters or 9·8 in. inside diameter and of 0·15 cubic meter or 5·3 cubic feet capacity each, tested for pressure up to 50 atmospheres or 735 lb. per square inch.

These two cylinders, which, owing to want of space within the car frames, had to be placed lengthways under the seats of the car, bring the total cubic contents of the 12 storage cylinders per car up to 2·12 cubic meters or 75 cubic feet divided into two groups, the working and the reserve battery, the former of 1·38 cubic meters or 49 cubic feet, the latter of 0·74 cubic meter or 26 cubic feet capacity, the total corresponding to 80 kilogrammes, or 177 lb., of compressed air under a pressure of 30 atmospheres or 440 lb. per square inch, and to 28·5 kilogrammes, or 63 lb., when the air has expanded to 10 atmospheres or 147 lb. per square inch. The division of this supply into a working and a reserve battery of $1{\cdot}38 \times 37{\cdot}7 = 52$ kilogrammes, and $0{\cdot}74 \times 37{\cdot}7 = 27{\cdot}9$ kilogrammes respectively, is made in order to insure a sufficient supply being always left for the last section of the return journey. This last section, from the terminal stopping place to the loading station at the depot, has a rise of 2·5 per cent., and lies in a curve of only 30 meters or 1·5 chain radius, necessitated by the want of space between the river on the one side and the steep slope on the other. Having regard to the grooved rails and the severe curve, the tractive force required for the empty car of 7·5 tons is here $7{\cdot}5 \times (25 + 20) = 337$ kilos., which corresponds to a pressure in cylinders of about 6·3 atmospheres. It was, however, found that at the end of one of the trial trips the remaining available pressure was insufficient to take the car up to the depot, and that the supply would therefore have to be increased. The deficiency could have been met by loading the cars at a pressure exceeding 440 lb. per square inch, but as a preferable alternative, the federal railway department prescribed the addition of the two small cylinders already referred to.

3. *Heating Chamber.*—This is placed in the center of the front platform reserved for the driver. It has the form of an upright cylinder with a dome-shaped cap, is 35 centimeters or 13·8 in. in inside diameter, and consists of sheet iron 1 centimeter or 0·4 in. in thickness, with an outer casing of the same meterial and an intermediate felt coating to prevent rapid cooling, the the cap having, moreover, a bright polished brass casing, which gives the chamber a neat and pleasing appearance. Into this water and steam cylinder, which has a capacity of 100 liters or 3·53 cubic feet, and is tested under hydraulic pressure up to 50 atmospheres or 735 lb. per square inch, the compressed air, contained in the working and reserve batteries, is admitted through an orifice at the bottom, and after rising through the water and steam, passes through the pressure valve into the working cylinders of the motors or the brake cylinders. The pressure valve of the regulator is kept down by a thin metallic plate, which is governed by a wheel and screw handle placed on the top of the cylinder cap and worked by the driver, there being, moreover, a safety valve to prevent the maximum working pressure of 12 atmospheres of 176 lb. per square inch from being exceeded under any circumstances. A pressure gauge fixed to the cylinder indicates to the driver at all times the pressure to which the air inside the valve box has expanded, while by means of a three-way valve the air, under reduced pressure, is allowed to pass either to the cylinders of the motors or to those of the brakes, or is entirely cut off. On the right of the driver there are fixed to the heating chamber three other valves, of which two, E and F used for loading air and steam, correspond to the two valves, E and F, at the loading station; and a third, G, placed above the other two, by which the air coming from the loading station is admitted into the working and reserve storage cylinders or batteries of the car, the pressure in these batteries being registered by two pressure gauges, one to each battery respectively.

4. *Brakes.*—Each car is provided with an air brake, consisting of a pair of small cylinders into which compressed air is admitted by the three-way valve already mentioned, and whose pistons act upon the brake blocks. Besides this air brake, each car carries a single-acting hand screw brake, which is used when the car is stationary or in the case of the air brake being defective.

5. *Car.*—There are 16 seats inside the car, and 12 standing places on the back platform, making 28 passengers, or, together with the driver on the front platform and the guard, at 75 kilogrammes or 165 lb. each, a load of 2·25 tons. The weight of the car, including compressed air, is 7·25 tons, the total weight therefore 9·5 tons, while the width is two meters, or 6·56 ft., and the total length 7 meters or 23 ft., the wheel base being 1·6 meter or 525 ft. The overhang of the back platform of 2·65 meters or 8·65 ft. is decidedly excessive, the more so as the load of 12 passengers and the guard which it has to support equals nearly 1 ton, or 45 per cent. of the entire passenger load, and is insufficiently balanced by the heating chamber and passenger load in the front part of the car. On the other hand, the closed part of the car, with only 16 seats, is too small and the car as a whole can certainly not be said to be well proportioned. The noiseless motion of the car renders a loud and effective caution signal necessary, and this, instead of the usual bell or whistle, consists of a bellow horn, the car showing, moreover, at night, large red and green lights on the right and left, and two large white lights with reflectors on the front or driver's platform, on which is also placed a small coke

stove which supplies hot water for heating the car during the winter season The cars are fitted with two buffers in front, and a coupling bar at the tail for attaching a trailing car, which, however, is never done on the Berne line.

Loading of Cars (Fig. 8).—This operation may be briefly described as follows: When a car has been brought into position at the buffer bar of the loading station, the corresponding two air and water orifices of the car and of the station are connected by intermediate spiral copper pipes. Owing to the condensation of steam in the heating chamber of the car, the chamber generally contains a sufficient quantity of water at about 70 deg. Centigrade except in the morning. When this has been ascertained, or the chamber has been refilled, steam is passed into the water under a pressure of about 6 atmospheres or 88 lb. per square inch, to bring the temperature up to 165 deg. Centigrade. At the same time, by means of the three-way valve, E, of the loading station, the storage and reserve cylinders of the car are connected with the accumulators in order to equalize the pressure of the residue air in the former. This done, the connection with the accumulators is cut off, and the same three-way valve is brought into position to admit the compressed air from the pumping main into the car batteries for loading. When the air in the car batteries has reached the maximum pressure of 30 atmospheres or 440 lb. per square inch, which is indicated by a pressure gauge, it overflows, viz., is turned off, automatically, into the accumulators for storage, thus preventing an overloading of the car batteries, and enabling at the same time the air pumps at the compressing station to continue working without interruption. This turning off is effected by two overflow valves under hydraulic pressure, one to each of the two sets of accumulators, which are fitted to a pipe connecting the compressed air main with the accumulators at H, and begin to play—viz., open automatically—as soon as the pressure in the compressed air main and in the car batteries exceeds 30 atmospheres or 440 lb. per square inch, as mentioned above. In order to insure the play of the valves taking effect at the right moment, the pressure in the accumulators has always to be kept somewhat below the maximum pressure in the compressed air main. At I there is another subsidiary connection between the latter main and the accumulator pipe, to be used in case of necessity, while at K and L two cut-off valves are placed in case of a similar emergency. The steam, air, and accumulator pipes are provided with registering gauges of ample size for reading off the pressure in each. With an experienced staff, the operation of completely refilling and loading an empty car in the morning and getting it ready for service takes about 30 minutes; that of reloading and turning a car during the day occupies about 15 minutes, the work of reloading, properly speaking, being performed in about eight minutes. Each car in its turn remains at the depot one day out of seven for the cleaning of the machinery and the regulating of the brakes.

(To be continued.)

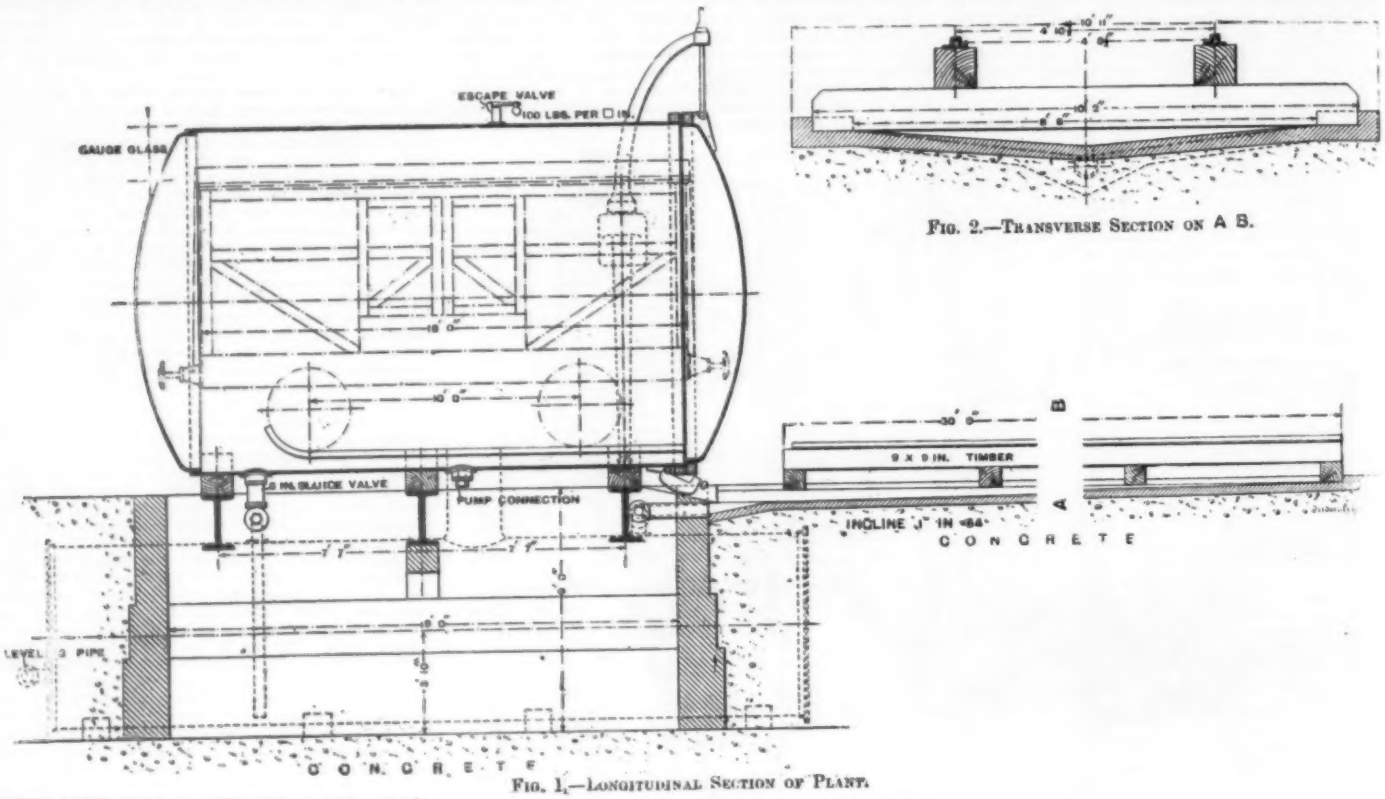


FIG. 1.—LONGITUDINAL SECTION OF PLANT.

FIG. 2.—TRANSVERSE SECTION ON A B.

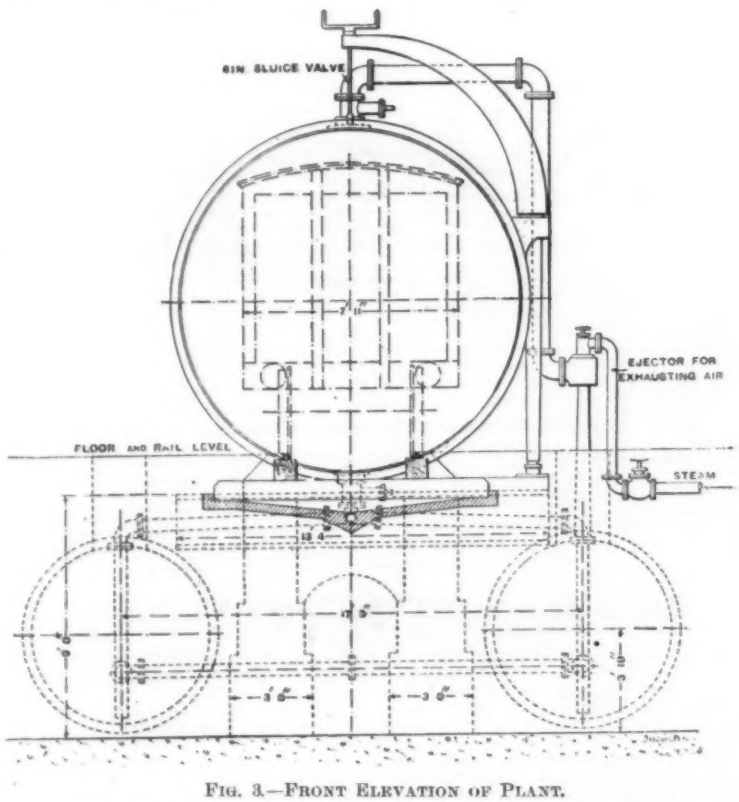


FIG. 3.—FRONT ELEVATION OF PLANT.

CREOSOTING RAILWAY CARS.

THE plant shown was constructed at the London & Northwestern Railway Company's Works, Crewe, and afterward successfully installed at their wagon works at Earlestown for the purpose of creosoting coal wagons and cattle trucks after they are put together. The illustrations, for which we are indebted to *Industries*, represent in Figs. 4 and 5 end views of the creosoting chamber without and with the truck in position, the latter being also shown with the cover entirely removed, and the former with the cover slung back, while Figs. 1 and 3 represent a longitudinal section and end view respectively of the entire apparatus.

The plant consists of a large cylindrical creosoting chamber, 12 ft 6 in. internal diameter by 32 ft. long, made of $\frac{5}{8}$ in. steel plates, and storage tanks for holding the creosote, which are placed below the ground in close proximity to the creosoting chamber, to which they are connected by pipes. The chamber is fitted with a glass gauge, pressure gauge, and escape valve loaded to give a pressure inside the chamber of 100 lb. per square inch. At one end of the chamber is a door or cover, which is supported by a crane fixed to the side of the chamber while a wagon is being taken in or out, and when closed it is held firmly in position by 48 cast-steel cramps, which are hinged to the chamber, the joint between the cover and the chamber, which is of the ordinary external and internal type, being made with lead As will be seen from Figs. 1 and 4, rails are fixed inside the chamber on which the wagon to be creosoted is run on its own wheels. As soon as a wagon has been run inside and the end cover made secure by the cramps before mentioned, a vacuum is created in the chamber by means of a Meldrum ejector, at the same time the creosote in the storage tank rises through the pipes into the chamber. As soon as it is almost filled, the connections with the ejector and storage tanks are closed by means of sluice valves, and connection opened to a force pump, which fills the chamber and raises the pressure to 100 lb. per square inch, the whole operation lasting about 20 minutes. The wagon is kept under pressure in the chamber for three hours, after which the sluice valve at the bottom of the chamber is opened, and the creosote runs back into the storage tanks. The wagon is then removed from the chamber and placed over a channel to drain the creosote, which is carried back to the storage tanks.

The springs of the vehicles are removed while the latter are in the chamber, and the whole of the plant is so well and economically arranged that it only requires one man at intervals during the day to look after and work it.

[FROM THE TECHNOLOGY QUARTERLY AND PROCEEDINGS OF THE SOCIETY OF ARTS, BOSTON.]

THE PHOTO-MECHANICAL PROCESSES.*

By S. R. KOEHLER.

IF we ask now what are the agencies by which the engraver and even the designer, the "artist"—that exalted personage, to whom we are accustomed to look up as a superior being more highly gifted than his fellows—are to be displaced, the answer may perhaps be something of a shock to delicately strung natures. There is, indeed, the glorious light, whose life-giving, silent, mysterious influence is called into play; but the bodies upon which it acts, and with which we shall have more tangible dealings, are of a much more terrestrial, lower, and vulgar order, to wit, *pitch*, *glue* and some *poisonous chemicals*. What mean substances! What an opportunity to moralize upon the exaltation of the little, or to preach upon the text that the stone rejected by the masons shall become the corner stone of the edifice! For if the engraver, and even the *artist*, are to be discharged to make way for pitch and glue, and are to be told that these despised bodies, which one cannot touch without soiling one's hands, are more reliable under the influence of light than their brains and hands under the same influence, what may not be in store for the rest of us?

* Read January 14 and 28 and February 25, 1892. Continued from SUPPLEMENT No. 902, page 14409.

Formulating the statement just made more concisely, we may say that the materials most generally used in the photo-mechanical processes are resinous substances, especially *asphaltum* (bitumen of Judæa, Jews' pitch); glutinous substances, more especially *albumen* and *gelatine*; and of chemicals, *potassium bichromate* and *ammonium bichromate*. Other substances have been tried, but those named may be said to be the only ones now practically in use, and we shall therefore confine ourselves to their consideration. The properties possessed by them which come into play in the photo-mechanical processes, and the possibilities which grow out of them, may be outlined as follows:

Asphaltum is a mineral resin of varying constituents found in Trinidad, on the shores of the Dead Sea, etc. It is soluble in benzine, benzole, and turpentine. Exposed to light, it undergoes what is apparently an oxidizing process, and becomes insoluble in its ordinary solvents. If, therefore, we coat a metal plate with asphaltum and then expose it to the action of light in parts, while other parts are protected from this action, as for instance under a negative, the result will be that after the exposure the coating is no longer uniform, but consists of asphaltum in two distinctly differing conditions, those parts of the coating which were protected from the light being still soluble in benzine, etc., while those which were exposed to its action have become insoluble. We can now wash away these soluble parts and can then etch the plate, the insoluble asphaltum left on it serving as an etching ground, or "resist," that is to say, protecting the parts covered by it from the action of the mordant. As not all the constituents of crude asphaltum are equally sensitive to light, it is purified for photo-mechanical purposes by treating it with ether.

Albumen, or white of egg, is soluble in cold water, not only in its fresh condition, but even after it has been dried. If, however, it is mixed with potassium or ammonium bichromate, dried, and exposed to light, it becomes insoluble and capable even, to a certain extent, of resisting acids. If, therefore, we coat a plate with a solution of albumen and a bichromate, dry it in the dark and then expose it to the action of light, while parts of it are shielded from this action, as under a negative, the result will be the same as in the case of asphaltum. We shall have on the plate albumen in two conditions, soluble and insoluble; and after the former has been washed away the plate can again be etched, the insoluble albumen acting as an etching ground or "resist."

Gelatine is best known to most of us as a material for delicate puddings. According to Professor Eder, who has made a special study of the subject, the term is used to designate "different kinds of pure glue without, however, applying to a particular species. In glue we distinguish *glutine* (bone glue, made from leather, parchment, bones, and isinglass) and *chondrine* (glue made from the cartilages of the ribs and joints). The properties of glue vary considerably, according to the preponderance of glutine or chondrine. Neither the one nor the other is found in commerce in the pure form; but nearly all ordinary commercial gelatines, and also most of the photographic gelatines (*i. e.*, those kinds specially made for photographic purposes), consist essentially of glutine." According to the same authority, the chemical constitution of these organic substances is as good as unknown; that is to say, we know that they consist essentially of carbon, hydrogen, nitrogen, and oxygen, but it is impossible to fix the proportions of these elements. Their action, however, under the influence of light in the presence of certain chemicals, is sufficiently understood, and upon this action are based the uses made of gelatine in the photo-mechanical processes.

Gelatine absorbs *cold* water, and consequently swells up when treated with it. In *hot* water it dissolves. It loses these properties, however, when exposed to light in the presence of a bichromate. The bichromates in contact with organic substances part freely with one equivalent of chromic acid under the influence of light, and the acid again is easily deprived of part of its oxygen and reduced to oxide. The ease with which chromic acid is thus decomposed is illustrated by bringing it together with alcohol. The deoxidation of the acid and the oxidation of the alcohol take place so rapidly that the latter ignites. According to Abney, when gelatine mixed with potassium bichromate is exposed to the action of light, the result is a loss of hydrogen and a gain of oxygen in the organic matter, and the formation of potassium hydroxide and chromic oxide. It would seem, however, as if the action could hardly be so direct. A film of sensitized or bichromated gelatine—of gelatine, that is to say, dissolved in hot water and mixed with a solution of a bichromate—spread on a glass plate and dried in the dark, is of a brilliant orange color. Upon exposure to light for a sufficient length of time it assumes a beautiful dark brown hue, said to be due to the presence of chromium chromate. This brown color disappears after copious washing in cold water, and the color that remains permanently is of a pale greenish tinge, caused by the presence of chromic oxide, and similar to the color of ordinary green glass bottles, which is also due to chromic oxide. The action of light on the bichromates in the presence of organic matter can also be illustrated by means of paper soaked in a solution of potassium bichromate, and it has been used for the production of a kind of sun prints called *chromotypes*. If a sheet of such paper, after it has been dried in the dark, is exposed to light under a negative, the picture is brought out in brown on an orange ground. Such a picture, however, is not permanent, as on further exposure to light after the removal of the negative the orange ground would also turn brown. To "fix" it, it is necessary, therefore, to wash out the unchanged bichromate; but this effects also the brown portions, and the picture is finally left in a greenish tint on white paper. Experiments like these, made by Mungo Ponton and published by him in 1839, were the starting point of all the processes based on the use of brichromated gelatine, although it was left to Becquerel to demonstrate, in 1840, that it was really the sizing matter of the paper which, in conjunction with the bichromate, produced the effect, and to Fox Talbot, in 1852, to investigate still further the action of the bichromates on organic substances under the influence of light.

The behavior of bichromated and unbichromated gelatine after exposure to light, and in the presence of hot and cold water, can readily be illustrated by means of the sheets of gelatine sold by dealers in photographic materials. If small pieces of such sheets are soaked in a solution of a bichromate, so that one-half is sensitized (bichromated) and the other half left in its natural condition, and then exposed to the light, and the half which has turned brown washed out until it assumes the greenish color, it will be found that upon immersion in *cold* water the part left in its natural condition will soften and swell, whereas the bichromated portion remains hard and leathery, and does not swell up at all, or at least very much less than the other half. This experiment may be repeated over and over with the same piece. If, however, a sheet of gelatine so prepared is thrown into *hot* water, the half of it which is in the natural state will dissolve, while the bichromated part remains hard and leathery as before.

A number of possibilities which have been utilized in the photo-mechanical processes grow out of the behavior of gelatine under the conditions just described.

A film of bichromated gelatine may be exposed under a negative, and then treated with cold water. It is evident from what I have told you that the unexposed parts will swell up above the exposed parts, which have lost the faculty of swelling, thus forming a relief in soft gelatine.

Such a film, after exposure, may be treated with hot water, which will dissolve out the unchanged gelatine between the parts that have been changed, and consequently hardened. The result is a relief in hardened gelatine.

The two possibilities so far stated are easily apparent from the experiments described. A number of others have been found, however, which do not follow so self-evidently:

A bichromated film may be so treated that after it has been exposed and then soaked in water it will accept printing ink on the exposed parts, the amount of ink accepted varying with the amount of exposure, while the unexposed parts, which have retained all their capacity for absorbing water, will reject it. It is evident that such a film acts like a stone with a lithographed drawing on it.

A film treated as described in the preceding paragraph shows a very fine reticulation or vermiculation on its surface. This "grain" can be made larger and more apparent, its closeness and size varying with the varying amount of light that has acted on the surface. Such a surface can be rolled up in ink, and transfers from it made to stone or metal.

A bichromated gelatine film, after full exposure to light, becomes impermeable to acids, while in those parts in which it has not been fully exposed the permeability varies in inverse proportion to the amount of exposure. It can, therefore, be used as a "resist" in etching processes.

Finally, bichromated gelatine, after exposure to light, shows a capacity for resisting the impact of the sand blast, the resistance varying with the amount of exposure. Upon this observation is based a photo-lithographic process.

We are now in a position to consider the various applications which can be made of the possibilities offered by asphaltum and bichromated albumen and gelatine. But as a matter of course we shall have to confine ourselves to the leading processes only, and more especially to those which are in practical operation to-day. And it will be well to state here, also, once for all, that only the leading principles can be touched upon. The innumerable great and small difficulties which beset the path of the photo-mechanical process man and make his lot anything but a happy one, but upon the successful overcoming of which, nevertheless, depends the commercial availability of his labors, must be ignored.

The first point to be considered is the character of

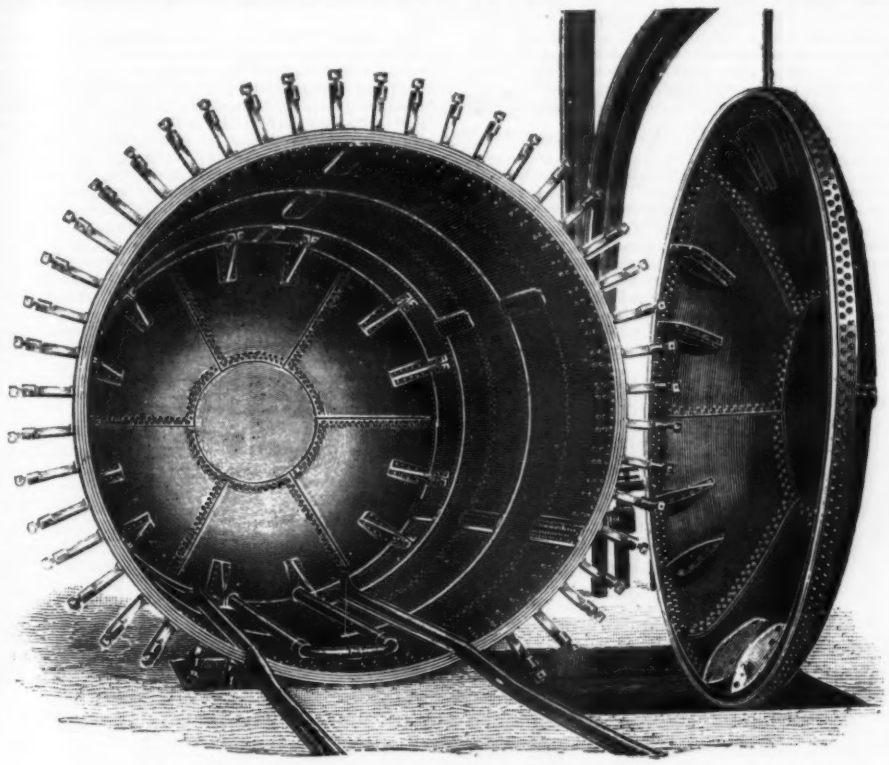


FIG. 4.—END VIEW OF CHAMBER WITHOUT TRUCK.

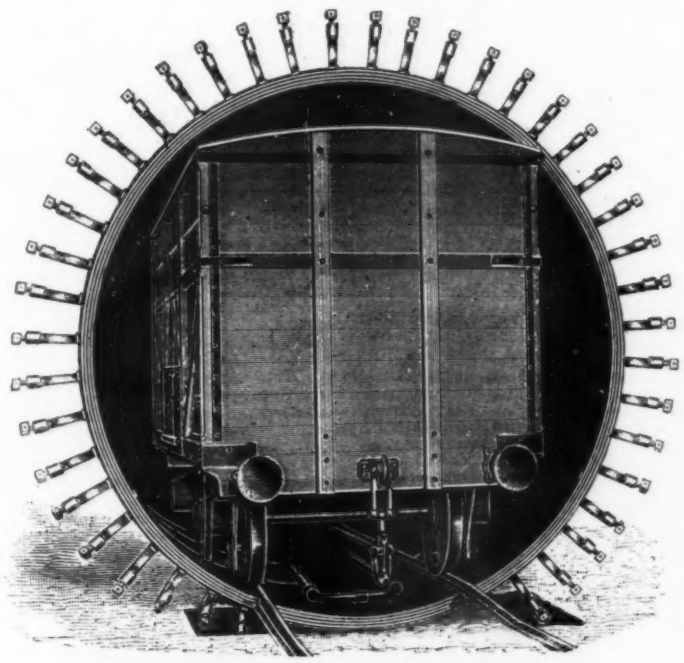


FIG. 5.—END VIEW OF CHAMBER CONTAINING TRUCK.

PLANT FOR CREOSOTING RAILWAY CARS.

the originals to be reproduced. These may be of two kinds: *First*, in lines and dots on a light ground, such as pen and ink drawings on white paper; and *second*, washed drawings, paintings and photographs from nature which show structureless grays. Originals of this second kind are commonly called "half-tone originals," and by this name we will designate them in our further discussion.

To begin with, we will take the simplest problem that can be proposed—the making of a relief block, to be printed in the book press, from a drawing in black lines and dots on white paper. The first care of the operator will be to examine the drawing. If it shows gray lines and dots intermingled with the black, he will, if it be at all feasible, reject it, as it will be impossible to get a perfect result from such a drawing. The reason will become apparent to you, if you will recall to yourselves the necessities of the surface-printing processes, which cannot, as we have seen, produce actually gray lines, but can only simulate them by substituting either finer black lines or lines broken up into dots by cutting through them (by white lining) for the gray lines of the original. This, however, the photo-mechanical process, presently to be considered, cannot do. To insure a perfectly satisfactory result, a black and white negative is needed, that is to say, a negative consisting of lines showing the clear glass without any veiling or obscuration whatever on a black ground of perfectly even density. It is obvious that a negative made from a drawing in which there are gray lines cannot fulfill these conditions, as some of the lines in it will be more or less veiled; and the result in the block produced will be either solid black lines where the gray lines should be, which will be too dark, or rotten lines, which will be ungainly, or no lines at all, which will give to the picture a spotted appearance, with contrasting black and white masses and no intermediate tones to unite them. A drawing for reproduction ought, therefore, to be executed on white paper in lines and dots of absolute black, varying only in breadth or size and in spacing.

Supposing the operator to be in possession of such a drawing, he will have the choice of three processes, now more or less generally in use, for its reproduction, to wit: the *etching process*, the *swell gelatine process* and the *wash-out process*. He is most likely to choose the first, and we will therefore begin with its consideration.

There are two varieties of the *etching process*, according to the nature of the substance used to produce the "resist," which substance may be asphaltum or bichromated albumen. Either will do, although asphaltum will perhaps give a somewhat sharper result. But as the albumen is a time-saver it is generally given the preference. In either case the first care will be to make a black and white negative from the drawing, generally somewhat reduced in size. This negative will have to be reversed, that is to say, instead of showing the right to left and the left to right, as in an ordinary negative, the right in it will have to be to right and the left to left. The necessity for this will become clear when the various changes of position are considered which the subject has to undergo in the process. The original is right-left; an ordinary negative would be left-right; the design on the block from such a negative would be right-left, and the impression would consequently be left-right. To prevent this the negative is made right-left, the same as the original. The block made under such a negative will, as a matter of course, be left-right, and the impression, consequently, right-left, as it ought to be.

A metal plate, generally a zinc plate, is now coated very thinly and evenly with a solution of purified asphaltum in benzole, or with a solution of albumen sensitized with either potassium or ammonium bichromate, and after it has been dried in the dark it is exposed to daylight or electric light under the negative. It is obvious that the light can penetrate only through the clear spaces of the latter, and, as these spaces represent the lines of the original drawing, that the result will be a reproduction of the drawing on the plate, in either hardened asphaltum or hardened albumen, while the spaces between the lines will be left in their soluble condition. The exposure having been completed, the next step will be the "development" of the image, or in other words the removal of the soluble parts from the plate. If asphaltum has been used, this "developing" is accomplished by washing with turpentine. If albumen has been used, the plate is first rolled up in a special kind of fatty ink (etching ink), so that it is uniformly black all over, and the "developing" is done with water. In either case the drawing is left on the plate in lines covered with a material capable of resisting acids, upon a ground of bare zinc. The plate is now in a condition to be etched into relief, for which purpose nitric acid diluted with water is used. After the etching has been completed it is generally necessary to trim the plate with the graver, *i. e.*, to make corrections and add refinements by reducing lines that are too thick, or to use the burnisher for the opposite purpose, and to rout out the large white spaces which it would be too tedious and costly to etch deep enough. The plate is finally made type high by mounting it on a block of wood like an electrotype, and it is then ready for printing from it in the type press, as from any other block engraved in relief.

I must put in a word here about the difficulties of etching as applied in these processes, which, as I told you before, demand of the etcher an extraordinary amount of skill and care. It will not do, as in the case of ordinary etching, to bite, take a proof and then, if need be, lay a rebiting ground merely on the surface and bite again. Not only the surface of the lines must be protected, but their sides as well, and this in corresponding progression downward as the biting progresses in depth. To this end the plate is rolled up with "etching ink" between the various stages of the etching, and powdered with resinous substances, commonly dragon's blood. The plate is then heated, so as to cause the ink and the dragon's blood to melt and gradually to coat the sides of the lines by flowing downward, first filling up the finest parts of the work, then the next finest, and so on until only the coarsest parts are left open for a final etching. In this way is secured not only sufficient depth between the lines to prevent the ink from filling up the block, but also a "foot" for each line, that is to say, increasing thickness downward, however delicate the line may be on the surface, so as to prevent its breaking under pressure. This species of etching was first practiced, as before noted, by the substitute process workers, and as it is said to have been more especially perfected by Gillot, of Paris, it used to be and still is occasionally called *gillotage*. The delicacy of this work can best be estimated by examining a half-tone block.*

The introduction of the electric light has made it possible to use the process here described, with albumen as the basis of the "resist" for quick newspaper work, which would be out of the question if sunlight were a necessity. The illustrations in the daily papers, whatever we may be tempted to think of them from other points of view, are certainly marvels of science applied to industry—a fact which the public, to whom they are presented at the breakfast table, does not sufficiently realize. An accident happens at noon; a small photograph is taken of the scene. This is enlarged, a drawing made over the enlargement, the photograph bleached out under the drawing, a negative made from the drawing, a plate coated, exposed, developed, bitten, trimmed, stereotyped and blocked, put on the press about midnight and a hundred thousand impressions or so distributed by six o'clock next morning. We are so surrounded by wonderful things that they cease to be wonderful. But it is well now and then to force ourselves to stop and think at least for a moment.

As the second possible method for the reproduction of our drawing I named to you the *swell-gelatine process*. In this case we shall need an ordinary—or as the professional slang has it, a "straight"—negative, that is to say, one that has not been reversed. From what follows, aided by the application of the right-left, left-right process, you will be able to reason out why. The first step in the swell-gelatine process is to lay a thin film of bichromated gelatine on a glass plate and to dry it in the dark. It is then exposed under the negative, the result being that those parts of the film which were acted upon by the light, and which correspond to the lines of the drawing, are hardened and lose their capacity of absorbing water and swelling, while the parts between the lines retain this capacity. It follows that, upon soaking the film in water after the exposure, those parts which were protected from the action of the light, and which correspond to the whites of the design, swell up, while those which were not protected, and which correspond to the blacks of the design, do not swell. The film in this condition represents a mould or matrix, and a cast taken from it could be used in the printing press, if it were of a material capable of withstanding the pressure. As this is not the case, however, a second matrix has to be made from the first cast, and from it a stereotype is obtained which is finished with the graver, etc., and routed where necessary, and then made type high by mounting it on a wood block.

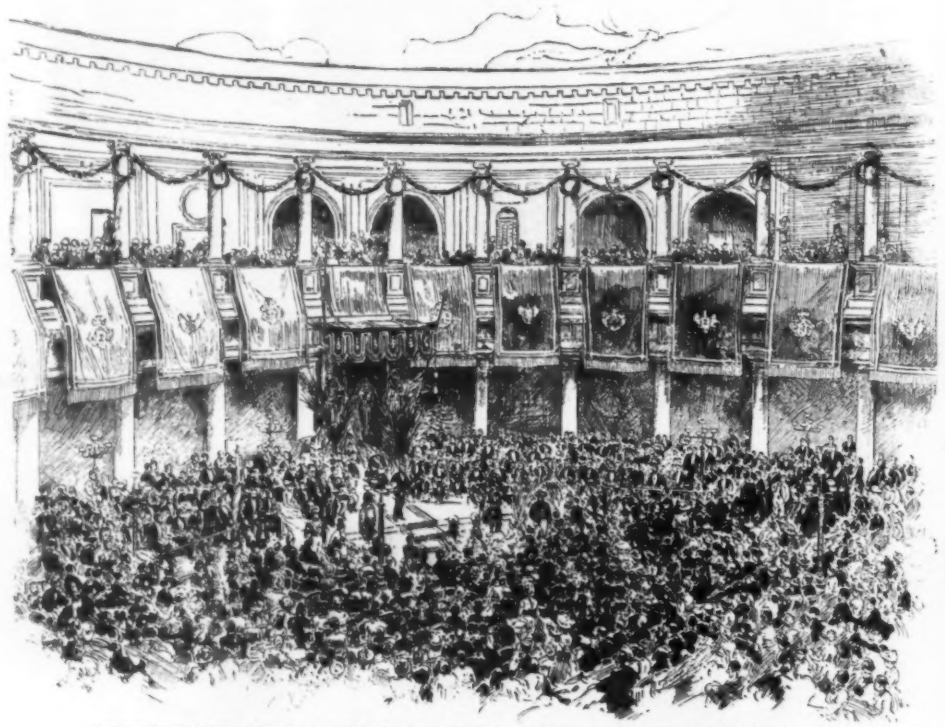
All the casting may be done in plaster; but the first cast is generally made in a soft mass, the composition of which each operator tries to hold secret. The swell-gelatine process, although patented by Poitevin, in 1855 (see his English patent of that year, No. 2,816), was specially brought to perfection by John C. Moss, of New York. †

A third possibility, finally, is found in the *wash-out process*. For use in this process the gelatine is first rotted, that is to say, kept in solution at a high degree of heat until it begins to decompose. It is an unfortunate characteristic of all so-called "practical" books never to give reasons or indulge in theoretical explanations. In accordance with this characteristic, none of the books that I have met with on the subject give any reasons for this rotting, and I have not as yet been able to make experiments in this process myself. It appears, however, that the rotting facilitates the washing out, without incapacitating the gelatine for setting. A thick film of this rotted gelatine, sensitized by admixture of a bichromate, is formed on a plate of glass, from which it is removed after it has set. The side which was next to the glass, and which is therefore the smoothest, is then exposed under the negative, which in this case must again be reversed. The exposure hardens the film under the clear spaces of the negative which represent the black lines of the original, but leaves it soluble under the dense parts, which represent the whites. The film cemented to a zinc plate is now treated with warm water for the purpose of washing away the unchanged gelatine between the hardened lines, leaving the latter standing in relief. As soon as sufficient depth has been obtained the washing away, or "development," is stopped. A film of this kind can be printed from, and this is actually done in the "glue-type" process. Usually, however, a wax mould is made from the film, and from this an electrotype.

The *planographic processes* for the reproduction of drawings in black lines, that is to say, those processes which produce designs on stones or zinc plates, printable in the lithographic press like ordinary lithographs or zincographs are of two kinds, to wit: *direct processes*, which produce printable pictures by the action of light directly on stones or zinc plates; and *transfer processes*, which involve the making of a picture on paper by the action of light, and a transfer from this to stone or zinc. As the transfer processes are the only ones now in practical use, we shall confine ourselves to them, and indeed to only one of them—the Osborne process, invented by J. W. Osborne, August 19, 1859, and patented by him in Victoria, September 1, 1859. It was the first process of its kind of practical value, and the changes introduced since its invention affect only matters of detail.

A sheet of paper, coated with albumen and gelatine sensitized by a bichromate, is exposed under a reversed negative. After the exposure the sheet is covered over its whole surface with lithographic transfer ink. In this condition it is floated on hot water to coagulate the albumen, and it is then "developed" with cold water. The cold water causes the gelatine on the sheet to swell, in which condition it has practically no affinity for the ink, while the wet sponge with which the sheet is rubbed for the purpose of developing it has a very great affinity for it. The sponge, therefore, removes the ink from the parts between the lines, but it does not remove it from the lines themselves, as the hardened gelatine which forms their basis has as much as or even greater affinity for it than the sponge. The office of the albumen is to hold the photographic image, after coagulation, with comparatively short exposure, to protect the paper during the development, and to hold the sheet on the stone during the transfer. Upon the completion of the development we have a drawing in transfer ink, that is to say, in an ink containing soap, on paper, and this drawing can be transferred to stone or zinc in the manner familiar to all lithographers, *i. e.*, by laying it down on a stone or zinc plate face downward, pulling the two through the press together, wetting the paper from the back and carefully removing it, which will leave all the ink on the stone or zinc, with scarcely a trace remaining on the paper. The stone or plate is now prepared in the usual manner, with acid and gum, and the result is a true lithograph or zincograph, differing in nothing whatever from a lithograph or zincograph made with lithographic ink and a pen.

(*To be continued.*)



CORONATION OF ZORRILLA AS POET LAUREATE, AT GRANADA, 1889.

JOSE ZORRILLA.

ZORRILLA is dead!—the poet who during the latter part of this century has produced the most precious jewels of a genuinely Spanish literature, continuing in an admirable manner the work of the classic writers of the golden age.

The daily press of Spain and other countries has published many biographies of the illustrious man

* A process is now coming more and more into use which does away with many of the difficulties of etching. The "resist" used is still held a secret, but is said to consist of bichromated albumen, mixed with other substances. It is laid on a copper plate and baked, which so hardens it that it resists acids without rolling up and powdering with resinous substances, and can be removed only by grinding. The nature of the copper and that of the mordant used, *i. e.*, perchloride of iron, make it possible to get sufficient depth and sufficient resisting power in the lines left standing by one etching, at least for ordinary purposes. It is stated that this "enamel resist" cannot be used on zinc.

† Since these lectures were delivered John Calvin Moss, born in Pennsylvania in 1838, died in New York, April 8, 1892.

whose death we mourn; why repeat, then, what has already been said? Who does not know where Zorrilla was born, how his father wished him to study law, and how he, rejecting the paternal advice, fled to Madrid, which offered such a wide field for his juvenile and high ambitions?

Who is ignorant of the penalties he had to suffer there before and even after his name became known and celebrated at the funeral of the illustrious Larra, at whose tomb, so to speak, the poet was born?

Afterward his compositions, El zapatero y el rey, Traidor, Inconfeso y mártir, Sancho García, Don Juan Tenorio and many others were produced on the stage with the greatest success, and his other poetical productions were received with applause. For a time he was the troubador of the court of the unfortunate Maximilian, and when he returned to Spain he was received with the greatest enthusiasm. His coronation took place in 1889 in the beautiful city of the Darro, which counts among its numerous glories that of having inspired the incomparable poem "Granada."

Zorrilla was the Spanish poet *par excellence*. He could admire the literatures of other countries, but they had no influence on his work, nor did the exigencies of what we might call fashion change in the least the flight of his inspiration; the subjects of his works are Spanish, and the form in which he clothed them is purely and genuinely Spanish; in his heroes we find that mixture of generous impulses and vices which forms the fundamental characteristic of the Spanish temperament—their movements are governed by impulse, not by calculation. Passion rules their bad as well as their good actions, making them appear grand even in their crimes; and finally, as the seal of his nationality, we may mention the perfection with which he wrote that truly Spanish meter, "Romance." He was a master in the art of writing, and had such perfect command of his rich and beautiful language, besides understanding the most hidden secrets of poetry making, that he could give the exact phrase to even the most subtile conception, and find the appropriate meter for the most intricate constructions, so that his inspirations were poured forth in verses of the greatest harmony; and in the most able and daring manner he unites, in some of his compositions, all the varieties of Castilian meter, besides some that are the creation of his own fancy.

¿Quién soy? ¿Quién lo sabe? Yo mismo lo ignoro.
Creyente sincero del Dios en quien fío,
á él solo me humillo y á él solo le imploro;
Sólo quiero le he hallado velando en bien mío;
Sólo quiero le bendigo, le canto y le adoro:
Sólo quiero sus creencias evoco con brío;
cantar mi fe firme no tengo á desdoro;
no tengo del pobre vergüenza ó duelo
mi pan con él parto, su mal con él lloro:
y no me da mengua recelo ni hastío
su sórdido traje, su oscura mansion.
Los mas escondidos rincones esploro,
y en todos á todos mi fé les confío,
contando á los unos un cuento sombrío
y haciendo con otros fervientes oracion.

AUTOGRAPHY OF ZORRILLA.

The rapidity with which he conceived and traced out the principal lines of his plots was extraordinary, but he was much slower in giving them form, and those who see the pages of beautiful round handwriting have no idea how many pages were struck out and how many verses altered before the compositions reached their perfect form.

Those who never experienced the delight of listening to his rendering of his compositions have no idea of the charm of his readings, which sounded like incomparable melodies. Now that beautiful voice is hushed, but the light of his genius will continue forever. He lived seventy-six years. Born in Valladolid February 21, 1817. Died in Madrid January 23, 1893.

For the above and the accompanying engravings we are indebted to our esteemed contemporary *La Ilustracion Artistica*.

THE TREATMENT OF BOILS BY BORIC ACID.

L'Union Medicale quotes Alison as having obtained good results in the case of general furunculosis by the administration for eight or ten days of from 10 to 15 grains of boric acid a day, divided into two doses. At the same time, four or five times a day, the inflamed areas were washed with a hot solution of boric acid, in the strength of four per cent. Between the applications of this lotion compresses were applied to the diseased parts, which had been wet with the same solution of boric acid. In this way he claimed to have been able to relieve the boils which had already formed, and to do much toward preventing other outbreaks. By this means he thinks it possible to avoid surgical intervention.

DON JOSE ZORRILLA, POET LAUREATE OF SPAIN

THE SACRED NILE.

By J. NORMAN LOCKYER.

THAT Egypt is the gift of the Nile is a remark we owe to the father of history, who referred not only to the fertilizing influence of the stream, but to the fact that the presence of the Nile and its phenomena are the conditions upon which the habitability of Egypt altogether depends. That that part of Egyptian archæology and myth which chiefly interests astronomers is also the gift of the Nile is equally true.

The heliacal rising of Sirius and other stars at the time of the commencement of the inundations each year; all the myths which grew out of the various symbols of the stars so used, are so many evidences of the large share the river, with its various water levels at different times, had in the national life. It was, in fact, the true and unique basis of the national life.

In this the Nile had a compeer, or even compeers. What the Nile was to Egypt, the Euphrates and Tigris were to a large region of Western Asia, where also we find the annual flood to have been in ancient times a source of fertility over an enormous area which is now a desert, the plains being broken by the remains of the ancient canals.

What more natural than that Euphrates, Tigris and Nile were looked upon as deities; that the gods of the Nile valley on the one hand, and of the region watered by the Euphrates and Tigris on the other, were gods to swear by; that they were worshiped in order that their benign influences might be secured, and that they had their local shrines and special cults?

The god sacred to the Euphrates and Tigris was Ea. The god sacred to the Nile was called Hapi.

The name Hapi is the same as that of the bull Apis, the worship of which was attributed to Mena.* Certainly Mena, Mini, or Menes, as he is variously called, was fully justified in founding the cult of the river god, for he first among men appears to have had just ideas of irrigation; and I have heard the distinguished officers who have lately been responsible for the irrigation system of to-day speaking with admiration of the ideas and works of Menes.

Whether the Tigris had a Menes in an equally early time is a point on which history is silent; but according to the accounts of travelers, the Tigris in flood is even more majestic than the Nile, and yet the latter river in flood is a sight to see—a whole fertile plain turned into, as it were, an arm of the sea, with here and there an island, which on inspection turns out to be a village, the mud houses of which too often are undermined by the lapping of the waves in the strong north wind.

There is no doubt that the dates of the rise of these rivers not only influenced the national life, but even the religions of the dwellers on their banks. The Euphrates and Tigris rise about the time of the spring equinox—the religion was equinoctial, the temples were directed to the east. The Nile rises at a solstice—the religion was solstical and the solar temples were directed no longer to the east. To the Egyptians the coming of the river to the parched land was as the sunrise chasing the darkness of the night; the sun god of day conquering the star gods of night; or again the victorious king of the land slaughtering his enemies.

By no one, perhaps, have the impressions produced by the various phases of the river been so poetically described as by Osburn, a writer of vivid imagination, but it must be added that the facts detailed in his description are not exactly capable of being verified by engineering science. Osburn thus describes the low Nile:

"The Nile has shrunk within its banks until its stream is contracted to half its ordinary dimensions, and its turbid, slimy, stagnant waters scarcely seem to flow in any direction. Broad flats or steep banks of black, sun-baked Nile mud form both the shores of the river. All beyond them is sand and sterility; for the hamseen, or sand wind of fifty days' duration, has scarcely yet ceased to blow. The trunks and branches of trees may be seen here and there through the dusty, hazy, burning atmosphere, but so entirely are their leaves coated with dust, that at a distance they are not distinguishable from the desert sand that surrounds them. It is only by the most painful and laborious operation of watering that any tint approximating to greenness can be preserved at this season even in the pleasure gardens of the Pacha. The first symptom of the termination of this most terrible season is the rising of the north wind (the Etesian wind of the Greeks), blowing briskly, often fiercely, during the whole of the day. The foliage of the groves that cover Lower Egypt is soon disencumbered by it of the dust, and resumes its verdure. The fierce fervors of the sun, then at its highest ascension, are also most seasonably mitigated by the same powerful agency, which prevails for this and the three following months throughout the entire land of Egypt."

Then at last comes the inundation:

"Perhaps there is not in nature a more exhilarating sight, or one more strongly exciting to confidence in God, than the rise of the Nile. Day by day and night by night its turbid tide sweeps onward majestically over the parched sands of the waste, howling wilderness. Almost hourly, as we slowly ascended it before the Etesian wind, we heard the thundering fall of some mud bank, and saw by the rush of all animated nature to the spot, that the Nile had overleapt another obstruction, and that its bounding waters were diffusing life and joy through another desert. There are few impressions I ever received upon the remembrance of which I dwell with more pleasure than that of seeing the first burst of the Nile into one of the great channels of its annual overflow. All nature shouts for joy. The men, the children, the buffaloes, gambol in its refreshing waters, the broad waves sparkle with shoals of fish, and fowl of every wing flutter over them in clouds. Nor is this jubilee of nature confined to the higher orders of creation. The moment the sand becomes moistened by the approach of the fertilizing waters, it is literally alive with insects innumerable. It is impossible to stand by the side of one of these noble streams, to see it every moment sweeping away some obstruction to its majestic course, and widening as it flows, without feeling the heart to expand with love and joy and confidence in the great Author of this annual miracle of mercy."

* Maspero, "Hist. Anc.," xi. 19.

The effects of the inundation, as Osburn shows in another place, "exhibit themselves in a scene of fertility and beauty such as will scarcely be found in another country at any season of the year. The vivid green of the springing corn, the groves of pomegranate trees ablaze with the rich scarlet of their blossoms, the fresh breeze laden with the perfumes of gardens of roses and orange thickets, every tree and every shrub covered with sweet-scented flowers. These are a few of the natural beauties that welcome the stranger to the land of Ham. There is considerable sameness in them, it is true, for he would observe little variety in the trees and plants, whether he first entered Egypt by the Gardens of Alexandria or the plain of Assouan. Yet it is the same everywhere, only because it would be impossible to make any addition to the sweetness of the odors, the brilliancy of the colors, or the exquisite beauty of the many forms of vegetable life, in the midst of which he wanders. It is monotonous, but it is the monotony of Paradise."

"The flood reaches Cairo on a day closely approximating to that of the summer solstice. It attains its greatest height, and begins to decline near the autumnal equinox. By the winter solstice the Nile has again subsided within its banks and resumed its blue color. Seed time has occurred in this interval. The year in Egypt divides itself into three seasons—four months of sowing and growth, corresponding nearly with our November, December, January, and February; four months of harvest from March to June; the four months of the inundation completing the cycle."

In order to show how the astronomy of the ancient Egyptians—to deal specially with them—was to a large extent concerned with the annual flood and all that depended upon that flood, and how the first solar year used on this planet, so far as we know, was established, it is important to study the actual facts of the rise somewhat closely, not only for Egypt generally, but for several points in the line some thousand miles in extent, along which in the earliest times cities and shrines were dotted here and there.

Time out of mind the fluctuations in the height of the river have been carefully recorded at different points along the river. In the "Description de l'Egypt" we find a full description of the so-called nilometer at Assouan (First Cataract) which dates from a remote period, perhaps as early as the fifth dynasty.

In Ebers' delightful book on Egypt space is given to the description of the much more modern one located at Rodah.

The nilometer, or "mikyas," on the island of Rodah now visible, is stated to have replaced one which was brought thither from Memphis at some unrecorded date. Makreezee in 1417, according to Ebers, saw the remains of the older nilometer.

The present mikyas is within a covered vault or chamber, the roof being supported on simple wooden pillars. In a quadrangular tank communicating with the river by a canal is an octagon pillar on which the Arabic measurements are inscribed. These consist of the pic (variously called ell or cubit)=0·54 meter, which is divided into twenty-four kirats. In consequence of the rise of the river bed in relatively recent times, the nilometer is submerged at high Nile to a depth of two cubits.

The rise of the Nile can now be carefully studied, as gauges are distributed along the river. We have the Aswân gauge from 1869, the Armant gauge from 1887, the Suhag gauge from 1889, and the Asyût gauge from 1882. The distances of these gauges from Aswân are as follows:

	Kilometers.
Aswân	0
Armant	200
Suhag	447
Asyût	500
Rodah	941

The Rodah gauge is not to be depended on, as the movements of the Barrage regulation destroy its value as a record. The heights of the zeros of these gauges above mean sea level are as follows:

	Meters.
Aswân	84·158
Armant	69·535
Suhag	56·00
Asyût	53·10
Rodah	13·14

Great vagueness arises in there being no very obvious distinction between the gauge readings reached in summer and that from which the rise is continuous. There are apparently rainfalls in the end of spring of sufficient power to raise the Nile visibly in summer, just as muddy rises have been seen in winter to pass down the valley, leaving a muddy mark on the rocks at Aswân and Manfalût. Independently of the actual gauge reading of the rise, there are facts about it which strike every beholder. At the commencement of the rise we have the *green water*. This occurs in June, but varies in date as much as the top of the flood varies.

From the fact that modern observations show that the very beginning of the rise, and the first flush, second flush, and final retirement vary, it seems evident that the ancient Egyptians could not have had any fixed zero gauge or time for the real physical fact of the rise, but must have either deduced from a series of observations a mean period of commencement, or a mean arrival of the red water, or a mean rising up to a certain gauge.

First to deal with the green water. Generally, when the rise of an inch or two is reported from the nilometer at Rodah, the waters lose the little of clearness and freshness they still possessed. The green color is the lusterless hue of brackish water within the tropics, and only the finer class of modern filter can render such water clear. The color is really due to algæ.

Happily, the continuance of this state of the water seldom exceeds three or four days. The sufferings of those who are compelled to drink it in this state from vesicary disease, even in this short interval, are very severe. The inhabitants of the cities generally provide against it by Nile water stored in reservoirs and tanks.

Col. Ross, R.E., noticed in 1887 and in 1890, when, owing to the slow retreat of the Nile, the irrigation officers had to hold back many basins in the Gizah province; and also in 1888, when the water remained long stagnant; that the basin water got green—showed the algæ and smelt marshy, just as the June green water does.

Hence it has been argued that as the Nile water in the bed of the stream—even in very slow-flowing back waters—does not become green, the greenness must be produced by an almost absolute stagnation of the water. We know of great marshes up above Gondokoro, and hence it is thought that the green water of summer, which comes on suddenly, is this marsh water being pushed out by the new water from behind, and that is why it heralds the rise. No one has so far minutely observed the gradual intrusion of the green water.

The rise of the river proceeds rapidly, and the water gradually becomes more turbid. Ten or twelve days, however, elapse before the development of the last and most extraordinary of all the appearances of the Nile, thus described by Mr. Osburn:* "It was at the end of—to my own sensations—a long and very sultry night, that I raised myself from the sofa upon which I had in vain been endeavoring to sleep, on the deck of a Nile boat that lay becalmed off Benisoueff, a town of Middle Egypt.

"The sun was just showing the upper limb of his disk over the eastern mountains. I was surprised to see that, when his rays fell upon the water, a deep ruddy reflection was given back. The depth of the tint increased continually as a larger portion of his light fell upon the water, and before he had entirely cleared the top of the hill it presented the perfect appearance of a river of blood. Suspecting some delusion, I rose up hastily, and looking over the side of the boat saw there the confirmation of my first impression. The entire body of the water was opaque and of a deep red color, bearing a closer resemblance to blood than to any other natural production to which it could be compared. I now perceived that during the night the river had visibly risen several inches. While I was gazing at this great sight, the Arabs came round me to explain that it was the Red Nile. The redness and opacity of the water, in this extraordinary condition of the river, are subject to constant variations. On some days, when the rise of the river has not exceeded an inch or two, its waters return to a state of semi-transparency, though during the entire period of the high Nile they never lose the deep red tinge which cannot be separated from them. It is not, however, like the green admixture, at all deleterious; the Nile water is never more wholesome or more deliciously refreshing than during the overflow. There are other days when the rise of the river is much more rapid, and then the quantity of mud that is suspended in the water exceeds, in Upper Egypt, that which I have seen in any other river. On more than one occasion I could perceive that it visibly interfered with the flow of the stream. A glassful of it in this state was allowed to remain still for a short time. The upper portion of it was perfectly opaque and the color of blood. A sediment of black mud occupied about one-quarter of the glass. A considerable portion of this is deposited before the river reaches Middle and Lower Egypt. I never observed the Nile water in this condition there, and indeed no consecutive observations exist of the reddening of the water. It is quite clear that the reddening cannot come from the White Nile, but must be the first floods of the Blue Nile and the Atbara coming down."

Rate of Rise of the Nile.—The rate in flood is 1¾ days from Wady Halfa to Aswân and six days from Aswân to Rodah (941 kilometers). In very high Niles this is perhaps accelerated to five days. In the early flood rising from say one cubit Aswân to six cubits, where there are many dry sand banks, and the spreading out of the river is considerable, and there is an absence of overlapping flushes from behind, the rate goes up to fifteen days. There is a very great difference in time and rate between Green and Red Nile. The rise is 45 ft. at Aswân, 38 at Thebes, and 25 at Cairo.

From the data obtained at the gauges named, which have been kindly forwarded to me by Mr. Garstin, the U. S. of State of the Public Works Department of Egypt, I have ascertained that the average time taken by the flood to travel now between Thebes and Memphis is about nine days. Although the river bed is now higher than formerly, the land around Thebes, according to Budge, having been raised about nine feet in the last 1,700 years, still the same elevation has taken place at Memphis, so that no difference in the velocity of the stream would be produced by this cause.

The great difficulty experienced in understanding the statements generally made concerning the Nile rise arises from the fact that the maximum flood is, as a rule, registered in Cairo upward of 40 days after the maximum of Aswan.

For the following account of how this is brought about I am indebted to the kindness of Colonel Ross, R. E.:

"The behavior of the flood at the Aswan gauge is as follows: Between August 20 and 30 a good average gauge of 16 cubits is often reached, and between August 27 and September 3 there is often a drop of about 30 centimeters. The August rise is supposed to be mostly due to the Blue Nile and Atbara River. Between September 1 and 8 the irrigation officers generally look for a maximum flood gauge of the year at Aswan. This is supposed to be the first flush of the White Nile. In the middle of September there are generally two small flushes, but the last twenty days of September are generally distinctly lower than that of the first week. The final flush of the Nile is seldom later than the 21st to 25th of September.

"All this water does not merely go down the Nile; it floods the different basins. The opening of these basins begins from the south to the north. This operation is generally performed between the 29th of September and the 22d of October. The great Central Egypt basins are not connected with the Nile for purposes of discharge into the river between Asyut and near Wasta, or a distance of 395-90 kilometers = 305 kil.

"The country in the middle or Central Egypt is broad, and thus there is an enormous quantity of water poured out of these basins into the lower reaches of the river about the 20th of October, which seriously raises the Nile at Cairo, and in a good average year will bring the Cairo gauge (at Rodah) up to the maxi-

* "Monumental Egypt," chapter i.

mum of the year on or about October 22, and hence it is that the guide books say the Nile is at its highest in the end of October.

"A gauge of 16½ cubits at Aswan while the basins are being filled does not give more than 21 cubits at Rodah (Cairo), but as the basins with a 16½ gauge will fill by the 10th of September, it follows that a 16½ to 16 cubit gauge at Aswan will not give a constant Cairo gauge, as the great mass of water passes by the basins and reaches Cairo. Hence we have frequently the paradox of a steady or falling gauge at Aswan showing a steady rise at Cairo.

"If the gauge at Aswan keeps above 16 cubits to near the end of September, the basin emptying is much retarded, as the emptying at each successive basin fills the Nile above the 16 cubit level; *hence the lower halves of the chains of basins do not flow off*, and thus when the great Middle Egypt basins are discharged, they do not raise the Nile so much as they do when the last half of September Nile is below 16 at Aswan.

"In years like 1887 and 1892, which differ from each other only in date of maximum gauge at Aswan, the river, having filled the basins in 15 to 20 days instead of in 25 to 30 days, comes down to Cairo in so largely increased a volume that a really dangerous gauge of 25 cubits at Cairo is maintained for over a fortnight (the average October gauge in Cairo is about 23 cubits), and from September 10 to October 25 the river remains from 24 cubits to 25½ cubits, and the Middle Egypt basins discharge so slowly that the opening day is hardly traceable on the Cairo gauge.

"In the 1878 flood, which was the most disastrous flood possible, the river rose in the most abnormal fashion, and on October 3 attained 18 cubits at Aswan. This breached the Delta and, in addition, so delayed the Upper Egypt basins emptying from the reason before given, that the wheat was sown too late and got badly scorched by the hot winds of March and April."* —*Nature.*

THE MISAPPLICATIONS OF THE TERM COCOA.

THE CORRECT USAGES FOR CACAO, COCA, COCO, AND COCOA.

By Dr. EUGENE MURRAY AARON.

NOT long since, while present in a recitation room in one of the higher grade schools in one of our leading cities, I had an opportunity to listen to the recitations of a class in physical geography, a class made up of children ranging in age from fourteen to seventeen. A reply made to a question from the teacher convinced me that the scholar making it was unaware of the difference existing between the trees producing the chocolate and the cocoanut of commerce. With the teacher's permission I put a question to the class which resulted in my discovering that not one among them was aware of the difference existing. My surprise was much heightened by discovering that the teacher was also in the dark on this matter, and to have the principal of the school, who entered just as I had finished a short talk to the scholars, when his assistant explained to him the subject of what I had been saying, reply: "Oh! yes; one is the nut of *the* palm tree and the other is a product from the sap."

It seemed beyond belief at first that such ignorance concerning two most prominent products of the nearby tropics could thus be confused; but I have since discovered that this was by no means an isolated case, rather being typical of the confused ideas that are common on the subject. Recently, on picking up that entertaining little work of Judge Bell in which he gives us the benefit of his observations in the West Indies, I came across these appropriate words: "Ideas at home [in England] on cocoa are generally very mixed, as most writers on the subject use various terms, such as cocoa, cacao, cocoa nut, cocoa palm, etc. The cocoa [*sic*] or chocolate is also often confused with the cocoanut palm."† I say *appropriate* words, because they are such inasmuch as they testify to the equally mixed impressions holding in England, and furthermore show that even the judge, who attempted thus to set his fellows right, still further mixes them up by applying the term cocoa to both the nut-bearing palm and the pod-bearing smaller tree.

Another illustration of this confusion of ideas is to be found in the last report of our own agricultural department, where in one place this accurate statement is to be found: "The chocolate plant, *Theobroma Cacao*, is highly valued for the produce of its seed. . . In this case *cacao* is the proper term to use when describing the plant or its products."‡ and where on another page, under the subject of adulterants, these products are invariably alluded to as "cocoa preparations," and the "cocoa bean."§ Our government is a prime offender in this respect, both the publications under the charge of the Smithsonian Institution and the Bureau of American Republics (State Department) being very careless in their use of these terms. It is a fact that throughout these bureaus, in the Government Printing Office, and in nearly every newspaper office in the land there is need that some primary instruction on this subject should be given to the proofreaders.

At a meeting of the London chamber of commerce in July last, Mr. J. Ferguson, while reading a paper on tropical agriculture in Ceylon, attempted to set this matter right by suggesting that the product of the chocolate-yielding tree should be known as *cocoa*, as it now is among uninformed people, and that that of the palm should drop the final *a* and be spelled *coco*. Unfortunately, Mr. Ferguson appears to have been unaware of the fact that this term is, by the claims of priority, the property of the tubers of *Caladium esculentum*, *Colocasia antiquorum*, and other allied species, that furnish an important starch-laden food in many tropical countries. Even the Century Dictionary, that monument of the industry of many industrious men, after setting those who consult it right by giving *cacao* as the correct spelling, uses the terms cocoa, cocoa shells, and cocoa butter, simply because they are the generally accepted inaccuracies.

There are four very distinct products that are mixed under the one term *cocoa*, and which in the minds of very many are all the products of the cocoa palm. These are:

Cacao [kah-ków] *Theobroma Cacao;* the chocolate berry tree.

Coca [ko-kah'] *Erythroxylon Coca;* the coca leaf bush.

Coco [ko-ko] *Caladium esculentum, et al.;* the coco roots.

Cocoa [kó-kwah] *Cocos nucifera;* the cocoanut palm.

Of these four, the first and last are best known in northern latitudes, both being very important articles of export from the tropical lands where they are grown; but of all of them there are certain interesting phases that are worthy of mention here.

Cacao, well placed in the genus *Theobroma* (food for the gods), derives its specific name from the Portuguese *Cacau*, which, according to Senor Jesus Sanches, is derived from the Mexican word *cacauatl*, a pure Nahuatl word. It belongs to the natural order *Sterculiaceæ*, is a small evergreen tree, like our apple, growing from 15 to 45 ft., is a native of tropical America, but has been introduced into Africa, where it has escaped from cultivation in some localities and may now be found growing wild. It bears a somewhat egg-shaped pointed pod, furrowed into 10 ridges, from 5 to 12 in. long, with a number of seeds buried in a sweet pulp. It is from the seeds that is derived the nutritive fat, about 50 per cent. of the whole, which is used as a food both in the fresh and dried state. Roasted and divested of their husks, they are known as "cacao nibs;" ground into a paste and sweetened and flavored, they yield "chocolate," the most important product of the tree; the nibs alone, either ground, unground, or in a crude paste, yield "cacao," erroneously called in English countries *cocoa*; with the oil thoroughly extracted, the dried powder yields "broma;" the husks alone furnish an article known as "cacao shells;" while the oil from the seeds is known as "cacao butter," which, with a chocolate-like taste and odor, is solid at ordinary temperatures, and is used for soaps, pomatums, suppositories, and like purposes.

The cacao tree, like the nutmeg and a number of other tropical growths, produces a curious impression, from the fact that the flowers and pods grow directly out of the bark of the trunk and branches, seemingly without any stalks, and not at the ends of the smaller stems. From Bulletin No. 7, Bureau of the American Republics, I extract the following:

"About 250 plants are ordinarily planted to the acre. The cultivation is very simple, consisting, after planting of the trees, in keeping down the weeds. During the first years banana plants are grown between the rows to shade the young plants and the soil. The first crop is taken in the fourth year from planting. The trees will produce, on an average, 200 fruits with from 30 to 50 nuts each, and a plantation of 50,000 trees would yield 550 tons of nuts. This, at 12·5 cents per pound, would give an annual income of $137,500. From this would be deducted:

"Preparation of 200 acres, purchase of seeds, care of seed beds, etc.	$14,000
Planting 12,500 banana plants to shelter plants	400
Pay of labor for care of plantation for four years	20,000
Total	$34,400

"The gathering and preparation of the nuts is estimated at about 1 cent per pound, and adding to this the cost of packing, transportation, and interest on capital, a net income of about $60,000 would result.

"A plantation of cocoa [*sic*] trees is an inheritance for the children of a family, as it produces from 50 to 80 years, and after the first few years needs little attention."*

An average temperature ranging near 80° F., a moist soil and a humid atmosphere are prime requisites for the successful cultivation of cacao. The belt along the Caribbean coast of Venezuela produces that prime article the "Caracas cacao," which is generally recognized as the best known to commerce, and is of that grade which all other countries are trying to copy. Speaking of the cultivation of cacao in that region, Bulletin No. 34, of the series already quoted, gives this much more moderate estimate of the results of the cacao plantation:

"One acre will accommodate about 100 trees, and like coffee, they must be protected from the sun by umbrageous trees, the banana, for instance, until they have acquired normal size. . . Five years after planting the trees begin to bear two crops per year, ripening in June and December. The average age of the tree is about forty years, during which time the crop will yield from 500 to 600 pounds per acre. . . The cacao crop pays for its cost with usury. It does not incur the risks that imperil the tobacco crop; it is safer, less expensive, and more profitable than stock raising or sugar growing, and is much more easily and cheaply gathered and manipulated than coffee."†

In Mexico, Jamaica, most of the Central American republics, and in the Windward Islands this crop is growing to be a prime favorite with those who are willing to wait a few years for a great return and who are not intoxicated by the almost immediate yield of the soil-exhausting banana.

Judge Bell, already quoted, has given on page 118 of his interesting little work this graphic description of a cacao plantation: "The cacao trees are planted in rows 15 ft. apart, and when full grown form a beautiful clean cultivation; the branches of each row interlacing with the next, form endless cool shady avenues, and carpet the ground with fallen leaves. The fruit grows in large red, yellow and green pods, ribbed somewhat like a melon (cantaloupe) and sprouting from the trunk and branches of the tree. When ripe, these pods are picked, cut open, and the beans found inside thrown into boxes and allowed to 'sweat' or ferment for five or six days; the beans are then taken out and spread out in drawers and mats, and after six or seven days' drying in the sun, are bagged and shipped to Europe."*

What I have written or quoted here of the present or very profitable productivity of the cacao crop has not been for the purpose of inducing northerners to try their hands at cacao cultivation in the tropics, as I am much of the opinion of Bell that "it is very much to be feared that in a few years the supply will exceed the demand, and these colonies, which persist in putting all their eggs in one basket, will at no distant date find themselves in the same predicament as they were in fifty years ago, with sugar." However, it is likely that for years to come it will remain an important factor in the earnings of many tropical belts, passing current in the place of money in some places, as it has long done on the upper Amazons.

Under the head of cacao the "cacao cuadrado," a wild species of the United States of Colombia, *Herrania pulcherrima*, and the "Guarana cacao" or "Guarana bread," as it is sometimes called, *Paullinia sorbilis*, are both to be borne in mind. The latter is a wild species of climbing, sapindaceous shrub, the pounded seeds of which contain *caffein*, and are made into rolls and cakes, used as food or as medicine, and in the preparation of a very refreshing drink.

From the last report of the Division of Chemistry, U. S. Agricultural Department, I extract the following on the subject of cacao adulteration:

"Perhaps no food material offers conditions so favorable for profitable adulteration and so well utilized by its manufacturers as do cocoa [*sic*] preparations. There is probably no more misleading or more abused term in the English language than 'soluble cocoa.' No cocoa in the market contains more than 10 per cent. to 30 per cent. of matter soluble in water, unless the material so dissolved is foreign soluble material that has been added during the process of preparation . . . This purpose may be accomplished in two ways; the material may be so finely divided that a very long time will be required for its deposition, or foreign substances (as starch or sugar) may be added to render the liquid of so high specific gravity or so pasty that the insoluble matter will not deposit. The first method is decidedly to be preferred; it accomplishes the object in view and puts the preparation in better condition for the action of the digestive juices, and all this without the addition of a cheap diluent that is always at hand in every kitchen should its use be desired."‖

Coca, the second of our four very distinct growths, is a product of the Andean chain from the United States of Colombia to Chile, though it is found in greatest luxuriance in the Peruvian Andes. This shrub is famed for the extraordinary stimulating properties of its leaves, which are known as "spadic" as well as "coca." They contain two alkaloids, cocain and hygrin, as well as a peculiar tannic acid. The Peruvians mix the leaves with the ordinary forage plants to increase the muscular energy and the endurance of their mules and llamas. There are many species of the genus *Erythroxylon*, but whether others of these contain the same valuable properties does not appear to have been ascertained. We in the United States are best acquainted with the product of the coca leaves at our soda water counters, where, as "wine of coca," "moxie," and as one of the ingredients of "coca kola," it is abused quite as much as used. In the latter case it is mixed with the wine of the kola nut, *Sterculia acuminata*, an African growth, the nutritive and revivifying qualities of which have already been sufficiently exploited by the surgeons of the German and British armies. Cocaine, another product of these leaves, is also a prominent factor in surgery. According to Baron von Mueller, more than $3,000,000 worth of coca leaves were exported from Peru as early as 1880.‡ This is a crop that might be introduced in the higher mountain areas of New Mexico, Arizona, and Utah, with profitable results.

The stimulating qualities of coca have not been generally overstated, remarkable as have been many of the claims made for it. I have made trips through tropical mountain ranges at a speed that was quite equal to that maintained by the most stalwart guides and which was only possible through these qualities of the leaf of the coca bush. A few leaves carried in the pocket make any other food supply unnecessary for a day's exhausting tramp; and I have seen a fagged pack mule so rejuvenated by having a few leaves put with his noontide feed that he was rather more frisky and unmanageable at 2 p. m. than he had been at 6 in the morning.

Coco, as already stated, is a name only to be properly applied to the roots of *Caladium esculentum*, *Colocasia antiquorum*, and allied plants. It is also applied to the yam-like roots of *Sechium edule*, more properly known as "chocho" or "chayota," a West Indian climbing plant, which, used as a culinary plant, yields a monster tuber capable of much the same treatment as our sweet potato, and the good sized fruits of which are also edible. The latter often germinate before they drop to the ground, and over 100 may be found on one plant in a year. None of these growths are of exportable worth at present, and are, therefore, of but little interest to northern readers.

The last of our quartette, *Cocos nucifera*, the cocoa nut palm, is so well known as a growth, from Florida to Chile, and its hand-shelled nuts, their desiccated interior pulp, and the many uses to which the fibers of the tree are put, make it so familiar to all that any description here would be but to reproduce what has already frequently been well done.

If what has here been said shall contribute to the clearing away of the very misty ideas of the great mass of readers regarding the use of the word *cocoa* and its allied terms, I shall feel that something has been gained; for at present the muddle into which careless writers and equally careless proofreaders have got these terms in a source of mortification to the English student, as it is a cause for surprise, and more, on the part of the German and Frenchman, who long ago learned to avoid these pitfalls and always follow the botanical distinctions.

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* The modern Egyptians still hold to the old months for irrigation. 7 Tuba = January 15 is commencement of wheat irrigation; 30 Misra is the last safe date for sowing maize in the Delta; 1st Tut is the date of regulating the bridges = September 8 in Upper Egypt.

† Bell, H. J.; *Obeah: Witchcraft in the West Indies.* London, 1889, p. 118.

‡ *Rept. of the Secy. of Agriculture;* 1891. Washington, 1892, p. 465.

§ *Ibid.*, p. 189.

* *Brazil*: Bulletin No. 7; Washington, June, 1891, p. 65.

† Venezuela: Bulletin No. 34, Washington, February, 1892.

* Bell, *l. c.*, p. 118.

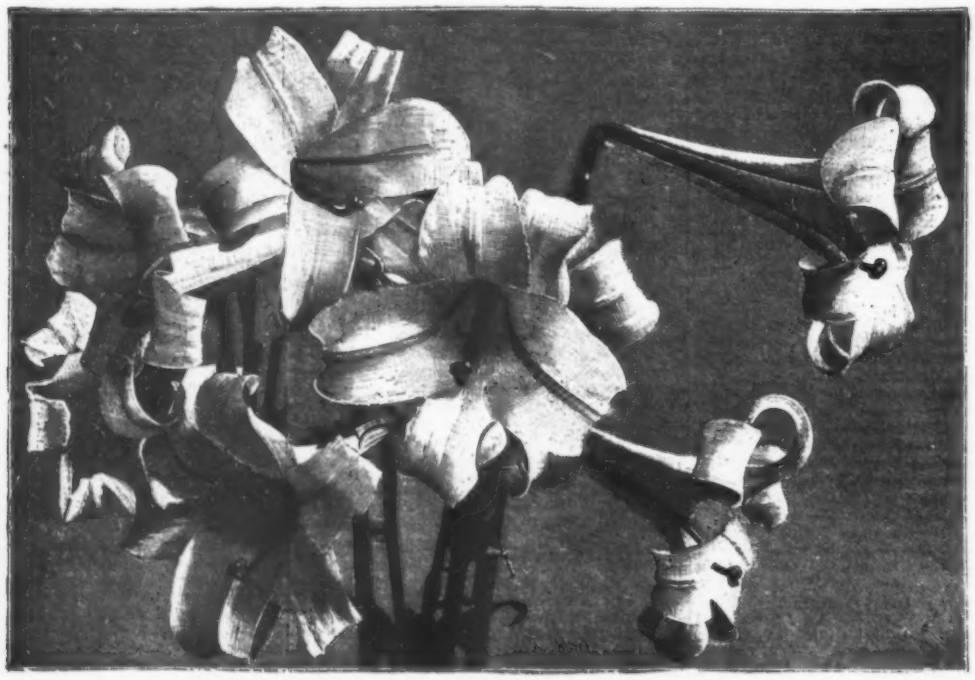
† Rept. of the Secy. of Agriculture, 1891; Washington, 1892, p. 189.

‡ I wish here to acknowledge the debt under which I, in common with all who are interested in tropical vegetation, am constantly put by the unrivaled work of Baron von Mueller, *Select Extra-Tropical Plants*, Calcutta, 1892, without which there would be a serious gap in botanical literature.

LILIUM LONGIFLORUM HARRISI.

THIS beautiful lily is evidently growing in popularity, and that rightly so. Being so amenable to pot culture for flowering at almost any season of the year, it is greatly appreciated, more particularly in the trade and by the florists and decorators. In many private gardens it is also grown, but its culture in this direction does not appear to be taken up so extensively as one would imagine, especially where large conservatories have to be kept gay, or where a quantity of choice cut flowers has to be provided. Only a few days ago I saw a house full of this variety in the best possible condition and in various stages of growth. The plants in bloom were some four feet in height, with from four to six well-developed flowers upon stout stems. The house in which these were being grown was kept at a stove temperature, warmth being evidently congenial to them. For the earliest flowering the bulbs should be secured as soon as they arrive from the Bermudas. This will be at about the same time as the Roman hyacinths arrive from the south of France. Forcing must not be attempted until some few roots have been made; then even the temperature should be worked up gradually for a time. By taking all possible advantage, the earliest may be had in flower during December, or even in November. Successions are easily obtained from that time up to May and June from the Bermuda importations. Those following in June, July and August I have a shrewd suspicion are Cape-grown bulbs. I have myself purchased them as such in the spring. Those blooming the earliest will give a few more flowers from succeeding growths the following autumn; thus the year is nearly or quite bridged over where necessary. Light loam and leaf soil, with plenty of sand or road scrapings, will suit this lily well. Green-fly is a troublesome pest, but can be kept down by the usual methods. This lily revels in a humid atmosphere when being forced, and takes water freely when well rooted. How it came to be designated Harrisi I do not know; I fail to see any difference between it and the type other than what may be expected in the case of vigorous bulbs grown under more congenial conditions in a warmer climate. This I consider makes all the difference, for I have noticed that Harrisi (so-called) reverts to the normal type after a season or two in this country. A good proof in support of this is the fact that L. longiflorum has been sought for in quantity in this country and on the Continent for sending out to the Bermudas, where after a season or two's growth they would return in the improved form to this country. The conditions under which the bulbs are grown is, in my opinion, the only cause of variation as seen between home-grown and imported ones. As to their culture at the Cape, it is only reasonable, being a means of further extending the season. This is done, we know, in the case of the tube-rose, why not also in that of the lily in question? A word upon the custom of the florists in depriving the flowers of their pollen vessels is necessary, the flowers being thus shorn of a part of their beauty. Why not dip or touch these parts with gum water instead, so as to prevent the pollen from tarnishing the flowers? Or wrap a little tissue paper around the vessels until the blooms are in actual use? Anything is better than thus robbing the flowers of a part of their attractiveness whenever and wherever it is possible.—SIMPLEX.

Messrs. Dobbie & Co., who kindly sent us the photograph by Messrs. Sweet & Kinloch, of Rothesay,



LILIUM LONGIFLORUM HARRISI.

say that the plant figured was potted in October in good turfy soil and sand, a 7 inch pot being used. After being plunged in cocoa-nut fiber refuse in a cold frame till well rooted, it was removed to a cold greenhouse, and flowered in July.—*Ed. The Garden.*

THE SMALLEST ELEPHANT.

In Casten's Panopticon, Berlin, is to be seen, so says the *Illustrirte Zeitung*, a diminutive elephant, called Lili, on account of its graceful appearance. It is three years old, according to the statement of Mr. Hagenbeck, who brought it recently to Europe from its home in Sumatra. Lili is only 90 centimeters high, 110 long and weighs 78 kilos., which is the minimum as to measure and weight. The normal weight of the elephant is from 3,000 to 3,500 kilos.

During the passage from Sumatra to Hamburg Lili enjoyed the special attention of the captain, who frequently gave her bananas in addition to her regular daily meal, which consisted of 1½ kilos. of the best pearl rice.

The little elephant princess now receives this rice with carrots. Such a small elephant has never been seen before in Berlin, and she awakens a justifiable interest. We hear her owner intends to cultivate the mental capacity of this remarkable babe elephant,

THE LITTLE ELEPHANT LILI, FROM SUMATRA.—FROM A PHOTOGRAPH.

with the hope of arousing a special interest in Hagenbeck's circus, which is to be one of the attractions at the Chicago Fair. Since the above was written the little animal has safely arrived in New York, *en route* for Chicago.

POSSIBILITIES OF THE TELESCOPE.*

By ALVAN G. CLARK.

A QUESTION sometimes asked is: "Will not a great increase in the size of lenses necessitate so much increase in thickness that a large amount of light will be lost by absorption?" In reply, I would say that we are a long way from experiencing anything very serious in this respect. The forty inch disks, already mentioned, have only a combined thickness of some four inches, and the lenses of an object glass of even six feet aperture would necessitate a combined thickness of not more than six inches. To be sure, this increased thickness means some more absorption, but not to the extent that some suppose, especially with the best glass now obtainable.

An experiment made at my manufactory will perhaps best illustrate just what I mean. I took a block of dense flint glass nine inches thick and polished on both edges. Behind this was placed common newspaper print, while in front of it sat a party who ordinarily, although not invariably, used glasses in reading. Through this nine inches of dense glass, however, he was able with perfect ease to read the whole newspaper article by lamplight, and without optical aid. But this nine inches in thickness is, as I have already said, much more than is necessary for even a six-foot lens, and who knows how soon still more transparent glass may be at hand, considering the steady improvement made in this line, and the fact that the present disks are infinitely superior to the early ones?

But even supposing a slightly larger per cent. of light is lost by absorption per unit of surface in a six-foot lens than in a three-foot one, yet the area of the larger will be four times that of the smaller, so that the total amount of light must be vastly greater.

Besides, every one who has had experience in using telescopes knows that even if two instruments of quite different sizes can both see the same object without trouble, the larger one has a decided advantage from the greater amount of light and the consequent increased ease and facility of seeing, which enables us to do better work. In illustration of the great light-collecting power of a large telescope, I may cite the fact that with the thirty-six inch refractor eighteen nebulæ were discovered at the Lick Observatory in a space only 16′ by 5′·5, and more recently a fifth satellite has been added to the planet Jupiter.

As regards the possible bending of great lenses under their own weight, although this sometimes occurs in a small degree, both sides are affected in a nearly compensatory manner, while in a mirror there is no such compensation. Any slight imperfection at any point on the surface of the lens, whether from defective workmanship or bending of the lens itself, produces much less error in the image than in the case of a reflector. The slightest imperfection of workmanship or distortion of the mirror from its own weight, as well as any difference of temperature between the front and back, will utterly ruin the image, while the performance of a lens would be much less affected by the same circumstances. Partly for this reason, reflecting telescopes very rarely give any such definition as refractors.

Then again, the refractor will give a much larger per cent. of the incident light than the speculum metal reflector. I speak of speculum metal reflectors because the difficulty of preserving the reflecting silver film on large silvered glass mirrors is so great, and the process of resilvering becomes so formidable that I believe them to be impracticable.

From what I have said, as well as from other considerations, which it is not necessary to mention here, I have not the slightest doubt that our future advance must be along the line of the refracting telescope.

Until a comparatively recent date wooden tubes were used for telescopes, but these being sluggish as regards equalization of temperature, a star image was often defective and showed wings before all the parts of the telescope had acquired the same temperature. This defect, however, has been completely eliminated by the introduction of the metallic tube, which, with a minimum amount of weight, gives a maximum amount of stiffness and produces uniformity of temperature very rapidly.

But in order that the object glass, as its size becomes so great, should also rapidly assume and constantly maintain uniformity of temperature in all parts, I have separated the crown and flint lenses in construction, so as to allow a free circulation of air between them. In the Lick telescope this separation amounts to some six inches with holes in the sides of the cell, thus allowing a free circulation of air between the lenses.

Thus we have to-day a refracting telescope that has steadily grown in size with increasing perfection in all its parts, and which has, beyond question, a still greater future before it. What the pledge of the past has been, the future will fulfill. What, then, are the possibilities of accomplishment for these great telescopes of the future?

We may answer that they will do great work anywhere, although much depends on the circumstances in which they are placed. For the finest work they

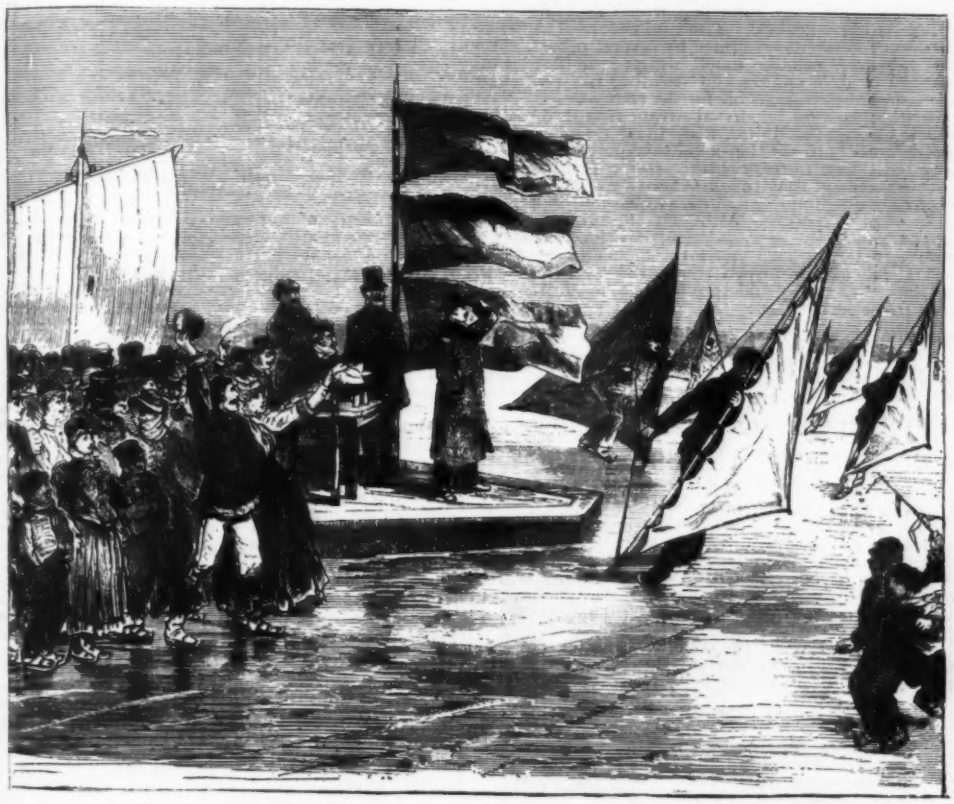
* Extract from article in January *North American Review.*

should have good atmospheric conditions, but these may be obtained at various places throughout the world, both at ordinary as well as higher altitudes. When used under such conditions much will be added to our present knowledge of astronomy.

The great and rapid strides which have lately been made in astro-physics, principally in the line of photometry, photography and spectroscopy, added to the vast amount of work which will always remain to be done in the older astronomy of motion, opens a field for the most powerful means of research. These monster telescopes may be characterized as the great light collectors and space penetrators of the universe, and their province, the solution of the ultimate problems of science.

REGATTA OF THE BERLIN SAIL SKATING CLUB, ON LAKE MUGGEL.

THE sport of sail skating won many adherents last winter, owing to the cold weather which lasted so long was the means of forming a Berlin club, as above. It will be seen from our drawing that the Berlin skaters have introduced a new system. A triangular sail is stretched on two bamboo sticks fastened together. The skater holds on to the vertical stick. The shifting of the sail, when required by the wind, is controlled by two cords that extend from the extremities of the stick. The club members wear the Holland skate. In using the sails the skaters place their feet one behind the other, not side by side, as formerly; this arrangement of the feet and skates forms a sort of longitudinal keel. In this manner all the movements of a good ice boat can be realized. The tacking and turning demand great skill on the part of the sail bearers, and yield them much pleasure. With a good wind a practiced sail skater can beat the best ice boat in rapidity. The above and our engravings are from *Illustrirte Zeitung*. The ice boat alluded to is doubtless the heavy and clumsy Dutch boat. No sail skater could keep pace with one of our Hudson River swift flying ice boats, which often make speed at the rate of forty or fifty miles an hour.



REGATTA OF THE SAIL SKATING CLUB, BERLIN.

[Continued from SUPPLEMENT, No. 902, page 14418.]

RECENT CONTRIBUTIONS TO THE CHEMISTRY AND BACTERIOLOGY OF THE FERMENTATION INDUSTRIES.

By PERCY F. FRANKLAND, Ph.D., B.Sc. (Lond.), F.R.S., Professor of Chemistry in St. Andrew's University, Dundee.

LECTURE IV.—BACTERIAL FERMENTATIONS.

THE fermentation phenomena induced by yeast, although of such enormous importance from a practical, commercial, or pecuniary point of view, are comparatively tame and uninteresting from the theoretical side, as compared with the varied changes which result from the vital activity of other micro-organisms. Whereas, in the case of yeasts, the number of substances acted upon is extremely limited, including only a few of the sugars, and the products of fermentation almost confined to alcohol and carbonic acid, in the fermentations induced by bacteria, on the other hand, not only are the substances attacked immensely more numerous, including both organic and mineral bodies of the most varied composition and constitution, but the products of fermentation are also greatly more diversified.

A great many of the investigations of these bacterial fermentations were made before the introduction of those exact methods for the study of micro-organisms to which I referred in my first lecture, so that they require practically in all cases a reinvestigation on a more sound basis. Much has already been done in this direction, but it is a mere fraction of what still remains.

Of these bacterial fermentations, the one which has longest been industrially recognized is the acetic or vinegar fermentation, the exciting cause of which was found by Pasteur, in 1864, to be an organism which, owing to its forming a skin on the alcoholic liquid, he named "mycoderma aceti," and which formerly had

FIG. 18.—MYCODERMA ACETI.

been known as "flowers of vinegar." He further showed that this microbe performs the function of an oxygen carrier in the reaction, and that if its vitality is impaired, aldehyde, instead of acetic acid, makes its appearance; while if the fermentation is allowed to continue after the whole of the alcohol has been transformed, then the acetic acid itself falls a prey to the oxidizing power of the organism, and is converted into carbonic acid and water.

Our knowledge of this remarkable and important fermentation has recently been greatly extended by Adrian Brown, who has shown that normal propyl alcohol can be oxidized by the mycoderma aceti to propionic acid, while methyl alcohol, isoprimary butyl alcohol, and amyl alcohol are all unaffected by it.

This mycoderma aceti is also able to exert its oxidizing powers on some polyhydric alcohols and on some of the sugars; thus, with glycol it forms glycollic acid; with glycerin, on the other hand, the oxidation is complete, carbonic acid and water being formed; with mannite, lævulose is formed; while with dextrose the result is gluconic acid. On cane sugar it has no action, nor on dulcite or erythrite.

Brown has also extended his investigations to the origin of the tough gelatinous mass which is often found on the vessels employed in the manufacture of vinegar, and which generally goes by the name of "vinegar plant," or "mother of vinegar." This material is found to be cellulose, and is produced by an organism closely resembling the mycoderma, but differing in the possession of the distinctive property of producing this jelly-like substance from either dextrose, lævulose, or mannite, but especially from lævulose. These transformations by the *Bacillus xylinus*, as this organism has been named, from its power of building woody fiber or cellulose, are of great theoretic interest.

Another very familiar and ancient fermentative change, which is much feared in many industries, is the so-called lactic fermentation, which takes place so readily in milk, and which consists in the conversion of the various kinds of sugar—generally milk sugar—into lactic acid. This has also been the subject of several recent investigations. In the ordinary lactic fermentation induced by the bacillus, which has been very thoroughly investigated, more especially by Pasteur, Lister and Hueppe, the lactic acid formed is inactive toward polarized light. Quite recently, however, another lactic fermentation has been discovered by Schardinger, induced by a totally distinct organism, and the lactic acid formed in this case is active, but, unlike the active lactic acid found in muscular tissue, it is lævorotary, instead of dextrorotary. On mixing equal quantities of these two active lactic acids in solution, the ordinary inactive lactic acid is obtained. The optical isomers predicted by theory, and of which the dextrorotary isomer has been well known since the classical researches of Wislicenus, are now completed through the discovery of this fermentation product. In fact, all three optical isomers are obtainable by fermentation, the lævorotary form by Schardinger's organism, and the dextrorotary one by an organism found by Nencki and Sieber.

Chemical science is, in fact, continually becoming more and more indebted to the work of micro-organisms, which are becoming indispensable reagents in the chemical laboratory, as it is only by their intervention that many substances are accessible. Their utility to the chemist depends generally upon their remarkable power of differentiating between closely similar substances. We have already noticed how differently the several members of the sugar group are affected by yeasts, some sugars undergoing ready fermentation by some particular form of yeast, while other sugars obstinately resist such decomposition. Similar phenomena of an equally remarkable character occur in connection with the bacterial fermentations.

Of this power of differentiation possessed by micro-organisms, I will bring before you an example which has recently occupied much of my attention in connection with a fermenting organism which I discovered some years ago, and to which I have given the name of *Bacillus ethaceticus* in consequence of its decompos-

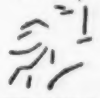


FIG. 19.—B. ETHACETICUS (Percy Frankland).

ing a number of substances with formation of ethyl alcohol and acetic acid as the principal products.

The caprice of this bacillus was first manifested in its attitude toward two substances which are both chemically and physically very closely allied, viz., mannite and dulcite. Thus:

	Mannite.
Occurrence	Numerous plant juices.
Taste	Sweet.
Melting point	166° C.
Crystalline form	Large rhombic prisms.

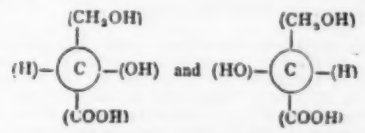
	Dulcite.
Occurrence	Numerous plant juices, but less frequently.
Taste	Sweet, but less so.
Melting point	188° C.
Crystalline form	Large monoclinic prisms.

Chemically they are still more similar, for one and the same formula has to do duty for both of them, thus:

$C_6H_{14}O_6$ or $CH_2OH.CHOH.CHOH.CHOH.CHOH.CH_2OH$.

Under these circumstances, it might have been anticipated that micro-organisms would adopt much the same attitude toward each of these substances, but, as a matter of fact, they distinguish between these two substances with the greatest readiness and promptitude. The *Bacillus ethaceticus*, for instance, sets up a vigorous fermentation in a suitable solution of mannite, while it refuses to have anything to do with the dulcite under the same circumstances.

But far more strikingly is this selective capacity displayed on introducing the *Bacillus ethaceticus* into a solution of calcium glycerate, in which it sets up a fairly vigorous fermentation, which comes to an end in about a fortnight. At the close of the fermentation, about one-half of the glycerate is found to have escaped decomposition; but while the calcium glycerate, before fermentation, had no action on polarized light, that which remains after fermentation is found, on examination with the polariscope, to be strongly lævorotary. Now, glyceric acid is one of those substances which chemical theory leads us to believe is composed of an equal number of dextrorotary and lævorotary molecules, combined together so as to form an inactive body—



OPTICAL ISOMERS OF GLYCERIC ACID.

The isomerism of these two glyceric acids is more easily understood by reference to the following geometrical figures, in which the particular atom of carbon, which in the above figures is surrounded with a circle, is represented by a tetrahedron, the four different groups with which it is connected being attached at the solid angles. It will be seen that these four groups can be arranged round the tetrahedron in two distinct ways (as in the figure), so that the two tetrahe-

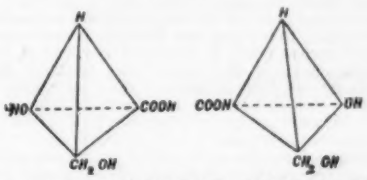


FIG. 20.—TETRAHEDRAL MODELS, REPRESENTING OPTICAL ISOMERISM OF GLYCERIC ACID.

dra cannot be superposed so as to make the several groups coincide; the two tetrahedra are in fact symmetrical but not superposable. This theoretical conception of the arrangement of the atoms in optically active isomers was originated by Lebel and Van't Hoff, in 1874, and has been of immense service in the investigation of the sugars and other bodies in which such isomerism occurs.

The *Bacillus ethaceticus* has the sagacity necessary

to distinguish between the molecules of these optical isomers which are combined in the ordinary inactive glycerate, and destroys the dextrorotary molecules by fermentation, while it leaves the lævorotary molecules untouched.

This lævorotary calcium glycerate crytallizes in beautiful monoclinic prisms, which exhibit hemihedral faces, while the ordinary inactive salt is not obtainable in a strikingly crystalline form at all.

A number of derivatives of this new active glyceric acid have been recently prepared in my laboratory, and their rototary power determined:

DERIVATIVES OF ACTIVE GLYCERIC ACID.

Formula.	Specific Rotation [α] D
$(C_3H_5O_4)_2$ Ba + $2H_2O$	— 9°
$(C_3H_5O_4)_2$ Sr + $3H_2O$	—10
$(C_3H_5O_4)_2$ Ca + $2H_2O$	—12
$(C_3H_5O_4)_2$ Cd + $1\frac{1}{2}H_2O$	—14
$(C_3H_5O_4)_2$ Zn + H_2O ...	—22
$(C_3H_5O_4)_2$ Mg + $2H_2O$	—18·5
$C_3H_5O_4$ Na	—16
$C_3H_5O_4$ Am	—20
$C_3H_5O_4$ K	—15
$C_3H_5O_4$ Li	—20·5
$C_3H_5O_4$ Me	— 4·8
$C_3H_5O_4$ Et	— 9·2
$C_3H_5O_4$ Pr(n)	—13·0

All these substances owe their discovery to the idiosyncrasy of my *Bacillus ethaceticus*, which leads it to consume the dextrorotary and to reject the lævorotary calcium glycerate.

FERMENTATION OF INDIGO BLUE.

In connection with bacterial fermentations, we may glance for a moment at one which has long been industrially employed in a very interesting manner in the art of dyeing.

Among the natural dyestuffs there is none enjoying a higher reputation, both on account of the fastness and the beauty of the colors obtainable from it, than indigo. There is, however, a peculiar difficulty in the way of applying the material as a dye in consequence of its insolubility in water and other liquids available for dyeing purposes. But although the indigo blue itself is insoluble in water, it can easily be converted into a colorless and soluble substance known as indigo white, by the application of suitable reducing agents. The fibers, etc., to be dyed can then be impregnated with a solution of this indigo white, and on subsequently exposing them to the air, the indigo blue is generated on the fiber by oxidation of the indigo white.

Now this reduction of indigo blue to indigo white for the purpose of dyeing was, until recently, invariably effected by a fermentation process carried on in what is known as the indigo vat.

The suitable medium for this fermentation is secured by mixing the following materials:

COMPOSITION OF INDIGO FERMENTATION VAT.

Wood Vat.

	Kilos.
Indigo	15
Woad	300
Bran	10
Madder	2—5
Slaked lime	12

Tank of water 2 meters wide by 2 meters deep. This is the vat most commonly used in Yorkshire for woolen dyeing.

Potash Vat.

	Kilos.
Indigo	10
Madder	2—5
Bran	2—5
Carbonate of potash	10—15

Made up with water in similar tank.

The organism which brings about this reduction of the indigo blue to indigo white has not yet been either isolated or scientifically investigated; the reduction is, however, generally supposed to be effected through the agency of nascent hydrogen generated in the fermentation, and if this is the case, there should be many micro-organisms capable of bringing about the result, hydrogen being one of the products in a number of fermentations. I am at present engaged in investigating the nature of this fermentative process.

[Experiment.—Demonstration of the indigo vat dyeing of cotton.]

BACTERIA CONNECTED WITH AGRICULTURE.

By far the most important changes resulting from bacterial life, which have been brought to light through recent scientific research, belong to the domain of agriculture, which we must indeed now regard as the most extensive and chief of the fermentation industries.

The recent investigations in this department have centered round what is undoubtedly one of the most important and, at the same time, perhaps the most mysterious of the elements, viz., nitrogen, which, though indispensable to all forms of life, is characterized by such apparent inertness in the free state. I say apparent inertness, for we shall presently see that recent discoveries have forced us to greatly modify our views on this particular point. To farmers the question of nitrogen is all-important, and we find even the most uneducated rustics with the word nitrogen on their lips.

It is with the nitrogen of the soil that we are more especially concerned this evening.

It is generally admitted at the present time that one of the most important plant foods in the soil is nitric acid; and scientific agriculturists inform us that if a soil were utterly destitute of this material, it would be incapable of growing the barest pretense of a crop, either of corn, or of roots, or of grass, even if the soil were in other respects of the most superb texture, however favorably situated, however well drained, tilled, and supplied with the mineral ingredients of plant food, such as potash, lime, and phosphoric acid.

Notwithstanding the commanding importance of this substance, nitric acid, to vegetation, it is present in ordinary fertile soils in but little more than homœopathic doses; indeed, it generally requires the most delicate chemical tests to demonstrate its presence at all.

[Demonstration of the presence of nitric acid in 1 lb. of garden soil by means of diphenylamine test.]

Thus in fertile soils there may be under some conditions as little as one part of nitrogen, as nitrate, in 1,000,000 parts by weight of soil, and often less than 10 parts, while sometimes again the proportion may be as great as 100 parts of nitrogen in the form of nitrate in 1,000,000 parts of soil.

That such minute quantities of nitric acid are present in soil is due mainly to two causes; first, the very soluble character of the nitrates, which occasions their being easily washed away by the rain; and secondly to the facility with which they are assimilated by plants, and which results in their being rapidly removed by vegetation. If rain and vegetation are excluded, the proportion of nitric acid, it has long been known, can be greatly increased in the soil. The soil, in fact, under ordinary circumstances continuously generates this nitric acid from the various nitrogenous manures which are applied to it, and it is in the form of nitric acid that the nitrogen of manures principally gains access as nutriment to the plant.

Already Pasteur, in the year 1862, had suspected that this production of nitric acid in the soil was the work of micro-organisms, but it was not until 1877 that this was actually proved to be the case by two French chemists, Schloesing and Muntz. These investigators demonstrated that the production of nitric acid, or process of nitrification, as it is commonly called, is at once arrested by all those materials which have the property of destroying micro-organisms, and which we call antiseptics, while, similarly, the process is stopped by heat and all other influences which are known to be fatal to life in general. The vital nature of the nitrification process was confirmed by several others, without, however, coming much nearer the important problem of determining and isolating the particular micro-organism responsible for the change.

Perhaps the most important advance in this direction was made by Dr. Munro, who, in 1886, showed that this process of nitrification could take place in solutions practically destitute of organic matter, which amounted to the statement that the vital activity of the bacteria of nitrification could be maintained without nutriment of an organic nature. Although this discovery was new as regards the bacteria of nitrification, it was not novel as regards some other forms of microbes; for, in 1885, I had already myself shown that some micro-organisms can actually undergo enormous multiplication, even in distilled water:

MULTIPLICATION OF MICRO-ORGANISMS IN DISTILLED WATER.

Hours after introducion of micro-organisms.	Number of micro-organisms found in 1 c. c. of water.
0	1,073
6	6,028
24	7,262
48	48,100

When I took up the subject of nitrification, in conjunction with my wife, in the autumn of 1886, I determined to make use of this remarkable property possessed by the nitrifying organisms of being able to flourish in the absence of organic matter, thinking that, in this way, it might be possible to achieve a separation of the nitrifying organisms from other forms, which can only grow if organic food materials are supplied to them.

The solution, which we employed for encouraging these nitrifying organisms to the exclusion of other forms, had the following composition:

COMPOSITION OF SOLUTION EMPLOYED FOR NITRIFICATION.

Ammonium chloride	0·5 grm.	In 1,000 c. c. of distilled water.
Potassium phosphate	0·1 "	
Magnesium sulphate	0·02 "	
Calcium chloride	0·01 "	
Calcium carbonate	5·0 "	

In a purely mineral solution of this composition we carried on the nitrification over a period of upward of four years, as shown in the following table.

But although this continuous cultivation of the soil organisms in a medium free from organic matter led to the elimination of a number of forms foreign to the nitrification process, it did not lead to a pure culture of the nitrifying organisms, for several other forms also persistently maintained themselves in this mineral solution. Various considerations, however, led us to the conclusion that the nitrifying organisms probably differed from the other forms which were still present along with them in being unable to grow on ordinary gelatine-peptone, for every attempt to isolate a nitrifying organism by gelatine plate cultivation proved fruitless.

It became necessary, therefore, to fall back on what I described in the second lecture as the "dilution process." For this purpose one of these nitrifying solutions was enormously diluted, and from this diluted liquid small portions were taken out, and each of these fractions was introduced into a separate ammoniacal solution of the same composition as that already indicated. In some of these solutions thus inoculated nitrification took place, showing that the nitrifying organism had been introduced; in others there was no nitrification, showing that the inoculation had not conveyed a nitrifying organism. Further, on examining

FIG. 21.

FIG. 21.—NITROUS FERMENT (Percy Frankland).

those solutions which had nitrified, it was found that most of them contained organisms growing on gelatine, while one, although it had nitrified, yielded no growth whatsoever on gelatine, while under the microscope it was seen to contain an abundance of bacteria having the form shown in the diagram.

EXPERIMENTS ON CONTINUOUS NITRIFICATION IN MINERAL SOLUTIONS.

Generation.	Date of inoculation.	Quantity taken for inoculation.	Date when nitrification was first observed.
I	9 5 1887	Original garden soil	20 5 1887
II	25 6 "	3 needle loops from I	30 6 "
III	1 7 "	" " II	7 7 "
IV	14 7 "	" " III	23 7 "
V	25 7 "	" " IV	17 8 "
VI	26 8 "	" " V	1 10 "
VII	3 10 "	1 needle loop from VI	3 10 "
VIII	7 10 "	1 needle point from VII	17 10 "
IX	7 10 "	" " VIII	29 10 "
X	7 11 "	" " IX	10 11 "
XI	1 12 "	" " X	15 12 "
XII	16 12 "	" " XI	23 1 1888
XIII	28 1 1888	" " XII	20 2 "
XIV	29 2 "	" " XIII	5 4 "
XV	7 4 "	" " XIV	27 4 "
XVI	30 4 "	" " XV	10 5 "
XVII	12 5 "	" " XVI	26 5 "
XVIII	19 7 "	" " XVII	3 9 "
XIX	3 9 "	" " XVIII	1 10 "
XX	11 10 "	" " XIX	20 11 "
XXI	24 11 "	" " XX	25 2 1889
XXII	26 2 1889	" " XXI	4 5 "
XXIII	28 6 "	" " XXII	18 10 "
XXIV	4 11 "	" " XXIII	17 12 "
XXV	27 12 "	" " XXIV	25 4 1890
XXVI	16 5 1890	" " XXV	8 7 "
XXVII	15 7 "	" " XXVI	30 1 1891
XXVIII	3 3 1891	" " XXVII	28 5 "

These results of ours were published in March, 1890, and about a month later there appeared in the "Annales de l'Institut Pasteur" a communication by M. Winogradsky, announcing the separation of a very similar, if not identical, nitrifying organism; while a few months later again a separation of a similar organism was made by Mr. Warington.

The method of isolation adopted by Winogradsky was different from ours, although likewise based on the incapacity of this organism to grow on gelatine. Pouring plates of a nitrifying solution, he allowed the colonies to develop; but having found by previous trial that none of these belonged to the nitrifying organism, he removed portions of the gelatine film lying between the colonies, thinking that the nitrifying organism must be present there; and on inoculating these portions of the gelatine destitute of colonies into suitable solutions, he actually obtained nitrification. You will remember that, in my second lecture, I referred to this particular method of using gelatine plate cultures for the isolation of organisms which refuse to grow on gelatine.

But these discoveries had not completely explained the phenomenon of nitrification, for the organisms separated in these three independent investigations possessed in each case only the power of converting ammonia into nitrous and not into nitric acid. Nitrous acid is an intermediate body which, curiously, is rarely found, excepting in very minute quantities in soil, nitric acid being comparatively far more plentiful. The changes will be more clearly understood by reference to the chemical equations:

(1) $\underset{\text{(Ammonia.)}}{NH_3} + \underset{\text{(Oxygen.)}}{3\,O} = \underset{\text{(Water.)}}{H_2O} + \underset{\text{(Nitrous acid.)}}{HNO_2}$

(2) $\underset{\text{(Nitrous acid.)}}{HNO_2} + \underset{\text{(Oxygen.)}}{O} = \underset{\text{(Nitric acid.)}}{HNO_3}$

The organisms separated by Winogradsky, by Warington, and by myself possessed only the property of effecting the first of these changes, they were absolutely destitute of the power of bringing about the second.

That this organism is unable to bring about the second of these reactions is particularly remarkable, inasmuch as this is the one which can be most readily accomplished by purely chemical means.

Thus the powerful oxidizing agent, potassium permanganate, has no action on ammonia, while it readily oxidizes nitrous to nitric acid.

[Experiment.—Add potassium permanganate to a solution of ammonium sulphate acidulated with sulphuric acid, the pink color of the permanganate is not discharged.]

[Experiment.—Add potassium permanganate to a solution of potassium nitrite, acidulated with sulphuric acid, the pink color of the permanganate is at once discharged.]

In fact, in order to bring about the oxidation of the ammonia by chemical means, we have to resort to one of the most powerful of oxidizing agents known to chemists, viz., ozone; but this agent, then, produces nitric as well as nitrous acid.

[Experiment.—Show the presence of nitrous and nitric acids in ammonia which has been submitted to the action of a current of ozonized oxygen.]

The power of oxidation possessed by our nitrifying organism is, therefore, altogether unique, doing as it does the arduous work of converting ammonia into nitrous acid, but absolutely refusing to undertake the trivial task of converting nitrous acid into nitric acid.

But how, then, is the nitric acid which is found in the soil produced, seeing that these organisms only yield nitrous acid?

At the time when I found that the organism which I had separated produced nitrous acid exclusively, I pointed out that it was doubtless explicable on one of the two following alternative hypotheses: (1) The

nitrous and nitric acids are produced by totally distinct organisms; or (2) one organism produces nitrous or nitric acid, according to the conditions under which it is growing.

More recent researches of Warington and Winogradsky have shown that the first of these two alternative hypotheses is the correct one; for, by making cultivations of soil in a solution containing nitrous acid and no ammonia, a micro-organism has been isolated which is endowed with the capacity of transforming nitrous

FIG. 22.—NITRIC FERMENT (Winogradsky).

into nitric acid, but has no power of oxidizing ammonia.

This second organism, or nitric ferment, as we may call it, resembles in its activity the purely chemical oxidizing agent, potassium permanganate, which, as we have seen, has no action on ammonia, but rapidly converts nitrous into nitric acid.

The process of nitrification in the soil now becomes intelligible in its entirety. It is the work of two independent organisms, the first of which converts ammonia into nitrous acid, while the second transforms into nitric acid the nitrous acid produced by the first.

Not only is this process of nitrification going on in all fertile soil, but enormous accumulations of the products of this process, in the shape of nitrate of soda, are found in the rainless districts of Chile and Peru, from where the Chile saltpeter, as it is called, is exported in immense quantities, more especially to fertilize the overtaxed soils of Europe. Thus, during the first six months of 1890 there were brought to the United Kingdom 90,000 and to the European Continent 480,000 tons of nitrate of soda from South America.

FIXATION OF FREE NITROGEN BY PLANTS.

There is yet another agricultural question of tremendous importance, both practically and theoretically, which I must touch upon in my lecture this evening.

For nearly a century past, agricultural chemists and vegetable physiologists have been debating as to whether the free nitrogen of our atmosphere can be assimilated by plants. This question was answered in

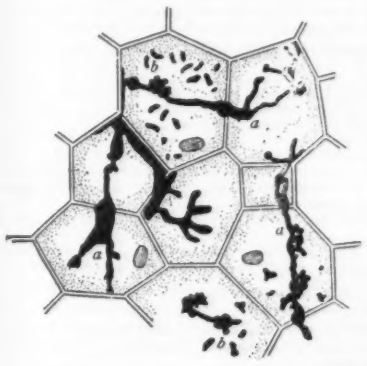


FIG. 23.—SECTION THROUGH TUBERCLE OF LEGUMINOUS PLANT. (After Laurent.)

a, ramifying growths extending through the polygonal plant cells; *b*, bacteroids present in small numbers only.

the negative by Boussingault about fifty years since. The problem was again attacked by Lawes, Gilbert, and Pugh, about thirty years ago, and their answer was in the negative also. In the course, however, of their continuous experiments on crops, Lawes and Gilbert have frequently pointed out that while the nitrogen in most crops can be accounted for by the combined nitrogen supplied to the land in the form of manures and in rain water, yet in particular leguminous crops, such as peas, beans, vetches, and the like, there is an excess of nitrogen found in the crop which cannot be referred to these obvious sources. It has, indeed, been known for 2,000 years that the fertility of the soil can be improved by the growth of leguminous crops.

The question remained in this unsatisfactory state

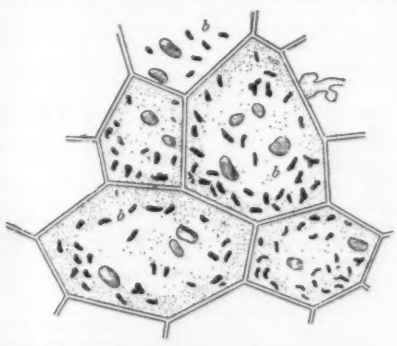


FIG. 24.—SECTION THROUGH TUBERCLE OF LEGUMINOUS PLANT, AT A LATER STAGE OF DEVELOPMENT. (After Laurent.)

b, bacteroids present in considerable numbers in each of the polygonal plant cells. The ramifying growth has disappeared.

until again revived by M. Berthelot in 1876, while subsequently the most conclusive experiments were made by two German investigators, Hellriegel and Wilfarth, who not only showed that this excess of nitrogen in leguminous crops is obtained from the atmosphere, but, what is more interesting to us, that this assimilation of free nitrogen is effected by means of certain micro-organisms flourishing in and around the roots of these plants, for when these same plants are grown in sterile soil the fixation of free atmospheric nitrogen does not take place.

The manner in which these micro-organisms assist these leguminous plants in the accumulation of nitro-

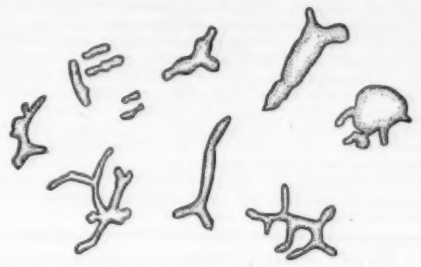


FIG. 25.—INDIVIDUAL BACTEROIDS, HIGHLY MAGNIFIED. (After Laurent.)

gen is exceedingly remarkable. When these micro-organisms are present in the soil, they occasion the formation of peculiar swellings or tuberosities on the roots of the leguminous plants, these tuberosities being never formed in sterile soil.

On microscopic examination these tubercles are found to contain among their cells a ramifying growth which subsequently gives rise to a number of small cells having much the appearance of bacteria, although the precise group of organisms to which they belong is one of those numerous points on which morphologists cannot agree. As long as this point is still *sub judice* it is perhaps most convenient to call these small bodies *bacteroids*. In the foregoing figures, which are prepared from the beautiful drawings of M. Laurent, the appearance of these ramifying growths and of the bacteroids to which they give rise are represented.

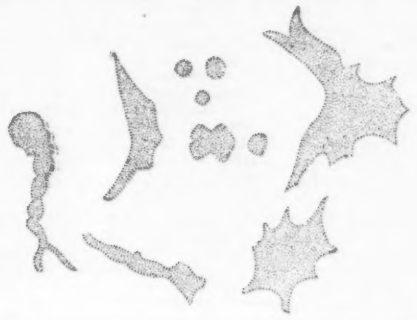
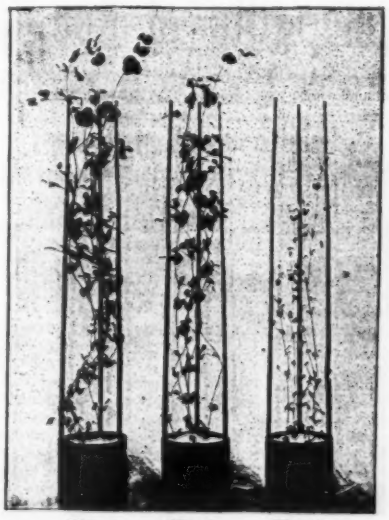


FIG. 26.—BACTEROID COLONIES ON GELATIN PLATE. (After Laurent.)

These bacteroids can be cultivated on artificial media like ordinary bacteria, and the next slide shows the appearance of some of the colonies to which they give rise on gelatine plate culture.

The careful investigation of these tubercle-producing organisms has shown that each species of leguminous plant has its particular bacteroid which is more potent in the formation of these tubercles on the given species than the tubercle bacteroids of other leguminous species. In this connection, some very striking and highly instructive experiments have been made by Prof. Nobbe, of Tharand.

This investigator has found that if pure cultivations of the bacteroids from a pea tubercle are inoculated into the roots of a pea plant, a more abundant growth and fixation of nitrogen by this pea plant takes place than if it is inoculated with pure cultures of the bacte-



No. 1. No. 2. No. 3.

FIG. 27.—PEA PLANTS. (After Nobbe.)

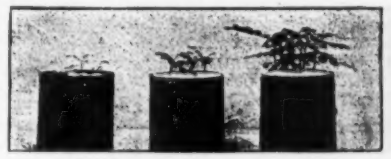
No. 1. Inoculated with pure cultures from tubercles of pea. No. 2. Inoculated with pure cultures from tubercles of lupin. No. 3. Inoculated with pure cultures from tubercles of robinia.

The inoculations were all made on Aug. 14, 1890, and the plants photographed on Oct. 9, 1890.

roids from the tubercles of a lupin or a robinia; while conversely, the robinia is more beneficially affected by the application of pure cultures from robinia tubercles than by those from either pea tubercles or lupin tubercles.

The exact manner in which the atmospheric nitrogen is rendered available for these leguminous plants possessing root tubercles is not perfectly understood, but the general impression is that the micro-organisms preeent in the tubercles take up the nitrogen and elaborate it into a form which can be assimilated by the plant. Whatever the secret of the process may be, it is perfectly certain that the presence and vital activity of the micro-organisms which give rise to the root tubercles is the indispensable factor.

The great importance of this discovery in vegetable physiology it is unnecessary for me to dwell upon. We have to recognize in these micro-organisms the in-



No. 1. No. 2. No. 3.

FIG. 28.—ROBINIA. (After Nobbe.)

No. 1. Uninoculated. No. 2. Inoculated with pure cultures from pea tubercles. No. 3. Inoculated with pure cultures from robinia tubercles.

The inoculations were made on June 27, 1890; the plants were photographed on Aug. 5, 1890.

valuable agents whereby the atmospheric nitrogen, which is in itself worthless, both to animals and ordinary plants, is actually rendered available directly for the nutrition of plants, and therefore indirectly for the sustenance of animal life on our planet.

I regret that the time has now come for me to bring to a close my discourse on the subject of these microscopic creatures which surround us, and which are in so many cases performing works of inestimable value. I must, in the first place, offer you my sincerest thanks for the kindness and patience with which you have listened to much which was doubtless not new to many. It has been my endeavor to present to you in outline the principal points which are at present exercising the minds of those who are devoting their lives and energies to the study of fermentation phenomena, using that term in its widest significance. From what I have said, you will see that the width of that significance is daily becoming greater and is all

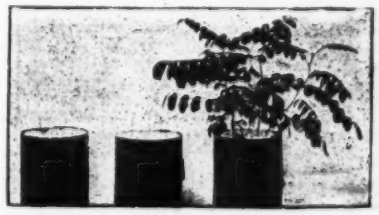
No. 1. No. 2. No. 3.

Photographed on Aug. 21, 1890.

FIG. 29.

but coextensive with life itself. As I have pointed out, the fermentation industries must no longer be supposed only to include brewing, distilling, wine production, vinegar manufacture, and a few others, as heretofore, but the principal fermentation industry, which is far more extensive than all the others put together, is agriculture itself.

The study of these fermentation phenomena is progressing with such rapid strides, and the accumulated material is already so overwhelming, that I have of necessity had to omit much that might have well found a place had time only permitted. If, however, in marshaling before you, as I have done, the recent discoveries in this branch of science, I shall have succeeded in arousing in any one here present such interest as will lead to his entering the ranks of the cultivators of this fertile domain of science in which so much still awaits the explorer's hand, then, indeed,



No. 1. No. 2. No. 3.

Photographed on Oct. 3, 1890.

FIG. 30.

my efforts will have been amply rewarded, the object and purpose of this course of lectures will have been realized and fulfilled.

CONVERSION OF ISOPRENE INTO CAOUTCHOUC.

By WILLIAM A. TILDEN, D.Sc., F.R.S.*

ISOPRENE is a hydrocarbon which was discovered by Greville Williams many years ago among the products of the destructive distillation of India rubber. Later, in 1884 [Trans. Chem. Soc., 45, 410], it was observed by myself among the more volatile compounds obtained by the action of a moderate heat upon oil of turpentine and other terpenes. It is a very volatile liquid, boiling at about 36°. Its molecular formula is C_5H_8, and it forms a tetrabromide $C_5H_8Br_4$, but no metallic derivatives like the two homologues of acetylene.

* From the Proceedings of the Birmingham Philosophical Society.

Bouchardat [Compt. Rend., 87, 654, and 89, 361, and 1117] observed that, when isoprene is heated to a temperature near 300°, it gradually polymerizes into a terpene, which he called diisoprene, but which is now called dipentene. This compound boils at 176°. A quantity of colophene, similar to that which is produced by the action of heat upon turpentine, is formed at the same time. When isoprene is brought into contact with strong acids—aqueous hydrochloric acid, for example—it is converted into a tough, elastic solid, which, examined by G. Bouchardat and by myself, appears to be true India rubber.

Specimens of isoprene were made from several terpenes in the course of my work on those compounds, and some of them I have preserved. I was surprised a few weeks ago at finding the contents of the bottles containing isoprene from turpentine entirely changed in appearance. In place of a limpid, colorless liquid, the bottle contained a dense sirup in which was floating several large masses of a solid of a yellowish color. Upon examination, this turned out to be India rubber. The change of isoprene by spontaneous polymerization has not, to my knowledge, been observed before. I can only account for it by the hypothesis that a small quantity of acetic or formic acid had been produced by the oxidizing action of the air, and that the presence of this compound had been the means of transforming the rest. The liquid was acid to test paper, and yielded a small portion of unchanged isoprene.

The artificial India rubber, like natural rubber, appears to consist of two substances, one of which is more soluble in benzine or carbon bisulphide than the other.

A solution of the artificial rubber in benzine leaves on evaporation a residue which agrees in all characters with a similar preparation from Para rubber.

The artificial rubber unites with sulphur in the same way as ordinary rubber, forming a tough, elastic compound.

The constitutional formula of isoprene is not known with certainty, but it must be selected from the five following formulæ:

$CH_3.CH.CH=C=CH_2$... } Derivatives of allene, $CH_2=C=CH_2$.
$CH_3.CH=C=CHCH_3$.... }
$(CH_3)_2C=C=CH_2$..... }

$CH_3CH=CH-CH=CH_2$ } Derived from crotonylene $CH_3=CCH_3-CH=CH_2$.. } $CH_2=CH-CH=CH_2$.

It is obvious that compounds such as these, containing doubly linked carbon, may polymerize in a variety of ways; and, in the present condition of our knowledge of the constitution even of isoprene, it would be idle to speculate as to which out of the numerous possible arrangements would correspond to the constitution of caoutchouc.

THE SIMULTANEOUS PRECIPITATION OF COPPER AND ANTIMONY BY THE GALVANIC CURRENT.

By W. HAMPE.

THE author shows that all the commercial brands of electrolytic copper which have been examined in his laboratory along with from 99·94 to 99·99 per cent. of copper always contained small quantities of antimony, in good sorts from 0·007 to about 0·02. This fact shows that in the technical elaboration by means of electrolysis small quantities of antimony are always precipitated along with the copper.

Also in the determination of copper, as practiced in the laboratories by the electrolysis of its sulphuric solution acidified with free nitric acid, antimony, if present, falls not only, as heretofore supposed, *after* the precipitation of the copper, but to a small extent also simultaneously. This fact must be taken into account in separations and in quantitative determinations of copper in order to avoid errors. The less antimony is present in the solution as compared with the copper, and the earlier the electrolysis is broken off, the less antimony is precipitated along with the copper. The tension and the density of the current are not without influence. The following observations indicate the quantities of antimony deposited along with the copper under defined conditions.

1. A copper sulphate containing 25·09 per cent. of copper, 0·0083 per cent. of antimony (corresponding to a copper with 0·033 per cent. of antimony), gave on the electrolysis of its saturated solution acidified with 20 c. c. nitric acid, with six Meidinger-Pincus globe elements, a copper containing 0·007 per cent. antimony.

2. 45·896 grammes of an alloy of copper and antimony were treated with nitric acid, whereon the antimony partly passed into solution and partly remained undissolved as antimonic acid. Without separating the latter from the liquid, it was evaporated down along with an excess of concentrated sulphuric acid until dense vapors escaped and the residue was taken up with water and 20 c. c. nitric acid. After the undissolved part of antimonic acid was filtered off it was submitted to electrolysis, the current being interrupted while the liquid was still distinctly colored. It contained, as appeared on its further treatment with hydrogen sulphide, etc., still 0·3644 gramme copper along with antimony. The latter, along with the antimony of the undissolved residue, amounted to 0·2338 gramme. The metallic deposit thus obtained electrolytically was of the finest rose color, like chemically pure copper. Its weight was 45·284 grammes. It was dissolved off the core by means of nitric acid; the solution was evaporated down with an excess of sulphuric acid until all nitric acid was expelled; the residue was taken up with water, and from the strongly acid solution the copper was thrown down by means of potassium sulphocyanide and sulphurous acid as a sulphocyanide.

The filtrate was worked up by well known methods, and was found to contain 0·009 gramme antimony which had been precipitated along with 45·275 grammes copper, so that the metallic precipitate had contained 0·0198 per cent. antimony. From the above data the composition of the original alloy is computed as 99·441 per cent. copper and 0·529 per cent. of antimony. It also contained 0·015 per cent. of iron.

It must be mentioned that the acids employed, prior to their use, had been freed from any antimony present. They had been diluted, treated with hydrogen sulphide, decanted, and again concentrated by evaporation.—*Chem. News.*

IS CONSUMPTION CONTAGIOUS?

RIFFEL has collated the statistics of births and deaths of all the families of a small district in Germany with special reference to this point, and from them comes to the following conclusions: There are very few families which in the course of time are not attacked by consumption, and when it once enters it is usually progressive, and by marriage propagates itself in other families, sometimes, however, sparing whole generations. The death rate among children in consumptive families is very great, especially where both parents have an hereditary taint; if one only is affected, it is immaterial whether it be the father or mother. The transmission of the disease from one person to another, or from husband to wife, or *vice-versa*, or through dwelling houses, could not be proved to have taken place. The children of phthisical parents often developed consumption, even if they had left their parents' house while still perfectly well, and had gone to other dwellings or even other localities.—*Boston Medical and Surgical Journal.*

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